FOREWORD INTRODUCTION

BARIUM CARBONATE

CAS N°: 513-77-9

SIDS Initial Assessment Report

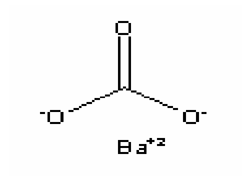
for

SIAM 20

Paris, France, 19-22 April 2005

1. Chemical Name:	Barium carbonate
2. CAS Number:	513-77-9
3. Sponsor Country:	Republic of Korea Contact Point: Myungjin Kim National Institute of Environmental Research (NIER). Kyungseo-dong, Seo-gu, Incheon, 404-708, Korea Tel: +82-(0)32-560-7124 FAX: +82-(0)32-560-7161
4. Shared Partnership with:	
5. Roles/Responsibilities of the Partners:	Solvay – Initial preparer of documents.
• Name of industry sponsor /consortium	Solvay, Belgium Contact person: Dr. Bruno Schmit SOLVAY DCRT/HSE Health and Environmental Risk Assessment Ransbeekstraat 310 B-1120 Brussels Phone: + 32 2 264 35 03 Fax: + 32 2 264 29 90
• Process used	Industry collected data, prepared the draft versions of the IUCLID dossier, SIAR and SIAP. All data have been checked, validated and edited by NIER, Korea.
6. Sponsorship History	
• How was the chemical or category brought into the OECD HPV Chemicals Programme?	This substance is sponsored by Korea under the ICCA Initiative and is submitted for the first discussion at SIAM 20.
7. Review Process Prior to the SIAM:	NIER, Korea peer-reviewed the documents and evaluated the quality.
8. Quality check process:	NIER, Korea peer-reviewed selected endpoints and verified the data in SIDS dossier with original studies.
9. Date of Submission:	21 January, 2005
10. Comments:	

SIDS INITIAL ASSESSMENT PROFILE

CAS No.	513-77-9
Chemical Name	Barium carbonate
Structural Formula	

SUMMARY CONCLUSIONS OF THE SIAR

Human Health

The toxicity of barium compounds depends on their solubility. Barium carbonate is less soluble than barium chloride. Since the toxicity of barium salts is mainly depending on the Ba^{2+} ion, barium carbonate is less toxic than barium chloride. So in nearly all sections the studies of barium chloride are used as surrogate to estimate the toxicity of barium carbonate. Distribution studies in rats showed barium, as chloride or carbonate, to be rapidly absorbed and distributed. 24 Hours after gastric intubation of barium chloride to rats, tissue concentrations ranked in the order of heart > eye > skeletal muscle > kidney > blood > liver, indicating retention in some tissues. Following intra-muscular injection of barium carbonate to rats, barium carbonate left the injection site very rapidly but resided in the bones with a biological half-life of 460 days.

Barium is not an essential element in human tissues. The metabolism of barium in mammals has been shown to be similar to calcium and strontium (all group II metals). The principal physiological activity of barium is stimulation of all types of muscles, irrespective of their innervations. The average daily human intake of barium is about 1.3 mg (0.65 - 1.7 mg). The human adult body contains 22 mg of barium of which 66 % is present in bones and estimated to have a half-life of 50 days. Excretion of barium is both fecal and urinary. Within 24 hours, 20 % of an ingested dose appears in feces and 5 - 7 % is excreted via the urine. Injection of a soluble barium salt results in increased urinary excretion compared to an ingested dose, but fecal excretion is still greater. Within 21 days, 90 % of the dose is excreted in a 1:9 ratio of urine vs. feces. Barium is found in newborn babies at concentrations higher than in adults; it crosses the lactational and placental barriers.

The acute oral LD_{50} of barium chloride in rats is 419 (males) and 408 (females) mg/kg bw. Ninety percent of deaths occurred within 5 hours of administration, and hemorrhagic areas in the stomach and inflammation of the intestines were observed in the primary necropsy. A second single dose study was conducted at three dose levels of 30, 100 and 300 mg/kg bw. At 300 mg/kg, 8 of 10 males and 7 of 10 females died within 24 hours, and the effects on body, liver and kidney weights after a single dose of 300 mg/kg bw appeared to be related to barium chloride. The same symptoms of the small and large intestines observed in the previous study (to determine the median lethal dose) were also seen at the high dose in both sexes. There were no chemical-related changes at doses of up to 100 mg/kg bw. Studies in dogs with infused barium chloride demonstrated the toxicity of barium ion, which is relevant to barium carbonate. The data showed that barium caused a reduction in plasma potassium, resulting in hypokalaemia and that barium also caused hypertension. There were no reliable animal acute toxicity studies by dermal and inhalation routes available.

The barium carbonate poisoning in humans initially stimulates striated, cardiac and smooth muscles and depresses serum potassium, which is forced intracellularly. Subsequent muscle weakness may result from a direct depolarizing effect and neuromuscular blockade. Symptoms are vomiting, severe abdominal pain, diarrhea, slow irregular pulse, muscle paralysis, dilated pupils, increasing somnolence, and cardiac arrest.

No reliable skin/eye irritation and skin sensitization studies were available.

In repeated dose toxicity studies, barium chloride dihydrate was given to F334/N rats and $B_6C_3F_1$ mice in drinking water for 13 weeks at concentrations of 0, 125, 500, 1,000, 2,000 and 4,000 ppm. The NOAEL value was estimated to be approximately 2,000 ppm, corresponding to an average daily dose of 110 and 115 mg Ba/kg bw to male and female rats, respectively, and 205 and 200 mg Ba/kg bw to male and female mice, respectively. This was based on mortality, decreased final mean body weights and mean body weight gains, decreased water consumption and renal toxicity. A similar study was conducted in the same species with the same concentrations of barium chloride dihydrate in drinking water for 92 days. The NOAEL of this study was 2,000 ppm (rats: 61 – 81 mg Ba/kg bw/day, mice: 165 – 166 mg Ba/kg bw/day) in the drinking water (based on depressed body weight gains and chemically related lesions in the kidney and lymphoid tissue for both species).

There are no *in vitro* or *in vivo* genotoxicity studies and no carcinogenicity studies of barium carbonate available. However, a number of in vitro genotoxicity studies of barium chloride dihydrate were conducted. Barium chloride dihydrate showed negative results in a bacterial reverse mutation test with *Salmonella typhimurium* strains (TA 97, TA98, TA100, TA1535 and TA1537) with and without S9 at concentrations of up to 10,000 µg/plate. In contrast, barium chloride dihydrate at concentrations of 250 µg/ml and above induced gene mutation at L5178Y mouse lymphoma cells in the presence of S9 mix while mutagenic activity was not observed without S9 mix. *In vitro* tests for sister chromatid exchange and chromosome aberration in Chinese hamster ovary (CHO) cells showed that barium chloride dihydrate did not induce chromosome changes up to the concentration of 3,000 µg/mL with or without S9 mix. No *in vivo* genotoxicity data was available. In conclusion, all except one *in vitro* genotoxicity studies were negative. The mouse lymphoma test gave an equivocal result only in the presence of an S9 activation system.

Concerning the carcinogenic potential, there was no evidence of carcinogenic activity of barium chloride dihydrate in drinking water to either sex of rats or mice that received up to 2,500 ppm for 2 years, corresponding to an average daily dose of 60 and 75 mg Ba/kg bw to male and female rats, respectively, and 160 and 200 mg Ba/kg bw to male and female mice, respectively.

Concerning the effect of Barium on reproduction and fetal development, the NOAEL for barium chloride dihydrate on fertility and developmental toxicity was 4,000 ppm for rats (the average dose was 201.5 mg Ba/kg bw/day for males and 179.5 mg Ba/kg bw/day for females) and 2,000 ppm for mice (the average dose was 206 mg Ba/kg bw/day for males and 199.8 mg Ba/kg bw/day for females). There were no treatment-related effects on pregnancy rates, pup survivals, pup weights, external abnormalities in both species except rats receiving 4,000 ppm exhibited marginal reduction in pup weights. No effect of barium chloride dihydrate could be detected on epididymal sperm counts, sperm motility, sperm morphology, testis or epididymal weight or vaginal cytology in either species up to 4,000 ppm in rats and 2,000 ppm in mice.

Environment

Barium carbonate is an odorless white inorganic solid. It occurs in nature as the mineral witherite. It is soluble in water at 24 mg/L at 25 °C, soluble in acids (except sulfuric acid) and in ethanol. It has a density of 4.3 g/cm^3 at 20 °C and negligible vapor pressure.

There is no evidence that barium carbonate undergoes environmental biotransformation other than dissolving to a divalent cation. Photodegradation and biodegradation are not relevant transformation processes. Under natural conditions barium will form compounds in the +2 oxidation state. Environmental fate modelling cannot be performed with the available data. Soil adsorption of barium was studied in a sandy soil and a sandy loam soil. Sludge solutions appeared to increase the mobility of elements in soil. Barium adsorption in algae increased proportionally with decreasing barium concentration in the medium. Bioconcentration of barium in fish was studied. BCF value for *Lepomis macrochirus* in male carcass was 74.4 (ug/g wet weight of bluegill tissue)/(ug/mL unfiltered water) so barium has a low potential for bioaccumulation.

In an acute toxicity test with barium carbonate on *Gambusia affinis,* a 96 hour TLm of >10,000 mg/L was determined. For *Daphnia magna*; a 48 hour EC_{50} of 32 mg/L was determined with barium. Barium was phytotoxic to the common duckweed, the 96 hour IC_{50} varying from approximately 100 mg/L to > 400 mg/L barium, the variability dependent upon site-specific water quality and in particular, the sulfate concentration. Chronic toxicity to aquatic organisms was studied. In a static renewal test using rainbow trout embryos and larvae, 4 day LC_{10} and LC_1 values of 9.5 and 2.8 mg/L were determined for barium (salt not specified). 30 day LC_{50} values of *Orconectes limosus* and *Austropotamobius pallipes pallipes* (crayfish) for barium chloride were 59 mg/L and 39 mg/L, respectively. 21 days LC_{50} value of *Daphnia magna* for barium chloride was 13.5 mg/L.

Exposure

Barium is the 16th most abundant non-gaseous element of the Earth's crust, constituting approximately 0.04 %.

The two most prevalent naturally occurring barium ores are barite (barium sulfate) and witherite (barium carbonate).

In 2001, 542,000 tonnes of barium carbonate were produced globally. In Korea the estimated production volume of barium carbonate was 26 626, 10 681, and 16 452 tonnes/year in 2002, 2003, and 2004, respectively.

Barium carbonate has a wide variety of uses; it is used in the production of television glass, crystal glass and special glass, frits and enamels, brick and tile, ceramic, magnets, electrodes, barium salts, paper, rubber, marble substitute and paints. It is also used for removing sulfates mainly in phosphoric acid production and chlorine alkali electrolysis and it is used as a rodenticide, an additive for glaze, an analytical reagent, oxidizing agent and filler.

In the production and processing facilities, workers might be exposed to barium carbonate dust by inhalation during handling, mixing or packaging the raw material. But in Korea and the EU, occupational exposure is controlled with personal protective equipments like goggles and dust filter masks and with ventilation. Korea has periodically collected monitoring data of occupational exposure. Based on the monitoring data from glass manufacturing factories, air concentration levels of total dust for workplace were less than 0.4 mg/m^3, which was below the permissible exposure limit of 10 mg/m^3 in Korea. In addition, the recorded airborne barium ranged from 0.0002 to 0.0004 mg/m^3, which is below the American Conference of Governmental Industrial Hygienists Threshold Limit Value (0.5 mg Ba/m^3).

The legal emission limits for barium carbonate range from 20 to 660 mg/m^3 for dust to air depending on the geographic location. There is no limit for waste to water outside a production plant.

The general population is exposed to barium primarily through ingestion of drinking water and consumption of food and beverages. Concentration of barium in seawater is 6µg/L and in fresh water 7 – 15,000 (average 50) µg/L. Ambient barium concentrations ranged from 0.0015 to 0.95 µg mg $/m^3$ in a USA survey. Barium concentrations of < 0.005 to 1.5 µg mg $/m^3$ have also been detected in the air of 18 cities and 4 suburban areas in the USA. Barium content in milk was found to range between 45 and 136 ug/g and in edible crops ranges from 10 ug/g in wheat to 3 - 4 mg/g in brazil nuts.

RECOMMENDATION AND RATIONALE FOR THE RECOMMENDATION AND NATURE OF FURTHER WORK RECOMMENDED

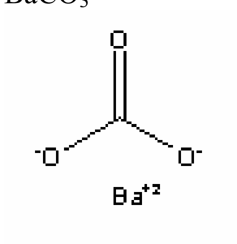
The chemical is currently of low priority for further work. The chemical possesses properties indicating a hazard for human health and the environment. These hazards do not warrant further work as they are related to acute toxicity which may become evident only at high exposure level. They should nevertheless be noted by chemical safety professionals and users.

SIDS Initial Assessment Report

1 IDENTITY

1.1 Identification of the Substance

CAS Number: 513-77-9
EINECS No: 208-167-3
IUPAC Name: Barium carbonate
Molecular Formula: $BaCO_3$
Structural Formula:



Molecular Weight: 197.34 (6)
Synonyms:
Barium salt
Barium carbonate (1:1)
Barium carbonate ($BaCO_3$)
Barium monocarbonate
BW-C3
BW-P
C.I. 77099
C.I. Pigment White 10
Carbonic acid, barium salt
Pigment White 10
UN 1564 (DOT)
Carbonic acid, barium salt (1:1) (24, 32)

1.2 Purity/Impurities/Additives

Purity: > 97 %

Impurity:
2.09 wt % Strontium carbonate ($SrCO_3$)
0.16 wt % Sodium carbonate (Na_2CO_3)
0.13 wt % Calcium carbonate ($CaCO_3$)
0.11 wt % Sulfite (SO_3)
0.003 wt % Ferric oxide (Fe_2O_3)
0.005 wt % Chloride (Cl^-)
< 5 ppm Nickel (Ni)
< 5 ppm Copper (Cu)
< 5 ppm Chromium (Cr)
< 5 ppm Cobalt (Co)
< 5 ppm Vanadium (V)
3.0 ppm Iron (Fe)

Source: Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay) (25)

Note: the above information corresponds to the commercial product from one producer.

1.3 Physico-Chemical Properties

Table 1 Summary of physico-chemical properties

Property	Value
Physical state	Solid
Substance type	Inorganic
Odor	Odorless
Color	White
Melting point	1,740 °C at 90 atmospheres (1)
Density	4.3 g/cm^3 at 20 °C (15)
Vapour pressure	Negligible
Water solubility	24 mg/L at 25 °C (6)
Partition coefficient n-octanol/water (log value)	Not applicable

2 GENERAL INFORMATION ON EXPOSURE

2.1 Production Volumes, Manufacturing Processes and Use Patterns

2.1.1 Production Volumes

The worldwide production of barium carbonate was 540,000, 540,000, 550,000, 580,000, 601,452 tonnes/year in 2000, 2001, 2002, 2003, and 2004, respectively.

In 2004, the split of the worldwide production by regions is as follows:

Country	Production volume (tonnes/year)	Country	Production volume (tonnes/year)
China	400,000	Europe	80,000
Nafta	35,000	India	30,000
Korea	16,452	Others	40,000

(30)

In Korea the estimated production volume of barium carbonate was 26,626, 10,681, and 16,452 tonnes/year in 2002, 2003, and 2004, respectively (25).

In Nordic countries the estimated production volume of barium carbonate was 2,017 tonnes/year in 2002 (37).

The estimated world production volume of barite ($BaSO_4$) among barium compounds was 5,890,000 tonnes/year in 1998 (16).

2.1.2 Manufacturing Processes

Barium carbonate is made using barium sulfide (black ash) dissolved in water and its clear solution is the usual raw material. There are two basic methods which differ mainly in the way the carbonate ion is introduced.

Soda ash method - barium sulfide is treated with sodium carbonate, either dissolved or in solid state, producing barium carbonate and sodium sulfide:

1) $BaS + Na_2CO_3 \rightarrow BaCO_3 + NaS$

This process depends on the market for sodium sulfide, the availability of cheap fuel, etc. The simplest method (equation 1) requires the largest investment as it requires the separation of sodium sulfide from barium carbonate and turning the sodium sulfide in to a saleable product.

2) $BaS + CO_2 + H_2O \rightarrow BaCO_3 + H_2S$

For the second method, carbon dioxide is available at low cost and in high concentrations from the smoke stacks of the black ash rotary furnaces. The hydrogen sulfide can be converted to sulfur compounds or to elemental sulfur.

The product from the straight gassing process tends to be less pure than the soda-ash method. The precipitation, washing, drying and grinding of barium carbonate is done in standard conventional equipment. Depending on the end uses, purity and size specifications are determined (19).

The production method of Solvay and the Korean production company is similar to the second method described above and the manufacturing process is as follows.

The companies produce barium carbonate from barium sulfate using the following process:

$BaSO_4$ + Petrol coke (C_2) (1200°C) $\rightarrow$ $BaS + CO_2$ (CO_2 dedusted by wet scrubbing)
$BaS + H_2O \rightarrow Ba(OH)(SH)$

$Ba(OH)(SH) + CO_2 \rightarrow BaCO_3 + H_2S$

$BaCO_3$ powder drying $\rightarrow$ granulation by heat

$H_2S \rightarrow$ (heat) oxidation to S (25, 30)

2.1.3 Use Patterns

Barium carbonate has a wide variety of uses; it is used in the production of television glass, crystal glass and special glass, frits and enamels, brick and tile, ceramic, magnets, electrodes, barium salts, paper, rubber, marble substitute and paints. It is also used for removing sulfates mainly in phosphoric acid production and chlorine alkali electrolysis, as a rodenticide, an additive for glaze, an analytical reagent, an oxidizing agent and filler (6, 25, 36).

In Korea, use processes for barium carbonate are as follows.

Barium carbonate is one of fifteen ingredients for manufacturing front glass of a television Braun tube. Barium carbonate and other materials are mixed and homogenized in the mixer, then moved to a smelting furnace. In this place barium carbonate is turned into BaO and CO_2 gas.

$BaCO_3 \rightarrow BaO + CO_2\uparrow$

Then, the melted mixture is moulded into glass plates (25).

Also, barium carbonate is used for manufacturing magnets in closed systems. Fe_2O_3 and $BaCO_3$ are mixed in water and ground in a mill and dehydrated. Then the material is heated at 1000 ~ 1200 °C. The overall reaction is as follows;

$$nFe_2O_3 + BaCO_3 \, (1000 \sim 1200\ °C) \rightarrow BaO \cdot nFe_2O_3 + CO_2\uparrow$$

After cooling and grinding, the Ferrite ($BaO \cdot nFe_2O_3$) powder is packed in 1 ton bags (25).

Barium carbonate is also used as an additive for ceramics glaze (25).

2.2 Environmental Exposure and Fate

Barium is the 16th most abundant non-gaseous element of the Earth's crust, constituting approximately 0.04 %. The two most prevalent naturally occurring barium ores are barite (barium sulfate) and witherite (barium carbonate) (46). The element is released to environmental media by both natural processes and anthropogenic sources (1).

Anthropogenic sources of barium are primarily industrial. Emissions may result from mining, refining, or processing of barium minerals and manufacture of barium products. Barium is released to the atmosphere during the burning of coal, fossil fuels and waste. Barium is also discharged to wastewater from metallurgical and industrial processes. Deposition on soil may result from human activities, including the disposal of fly ash and primary and secondary sludge in landfills. Estimated releases of barium and barium compounds to the air, water and soil from manufacturing and processing facilities in the USA during 1998 were 900, 45, and 9,300 tonnes, respectively (46). According to the US-EPA Toxics Release Inventory (TRI), , releases of barium compounds into the environment in 2002 were as follows (tons).

Air	Water	Land	Underground Injection	Total On Site Releases	Total Off- Site Release	Total On and Off-Site Releases
1,042.2	573.6	73,633.3	16.4	75,265.6	21,505.6	96,771.3

(47)

Releases into the environment of barium carbonate may occur during production and processing in the Sponsor country. Only one company (Onsan; joint venture of Solvay) produced barium carbonate in Korea by April 2004. In the production facility, barium carbonate may be emitted to air and water. In the stack of the factory, filtered dust is emitted to the atmosphere. No data is available for measured concentration of barium carbonate but measured concentration of total dust in the stack is under the environmental regulation standard for total dust in the air. 70 % of the total wastewater is recycled and the rest is treated and discharged to the wastewater plant.

Barium carbonate is mainly used as a raw material in the electrical engineering industries for glass production, a raw material in the magnet manufacturing industry and as an additive in the ceramic industry in Korea. In the processing facilities, barium carbonate may be emitted to air, water and soil. Filtered dust is emitted to air and attached dust in the filter is recycled or deposited in the landfill. Wastewater is recycled or treated in the wastewater plant. Treated wastewater is discharged to water and sludge is deposited in landfills (25).

Solvay has two production plants, one in Honningen, Germany and the other in Massa, Italy. Solvay also has joint ventures with three other plants in Onsan (Korea), Monterrey (Mexico) and Kalahasti (India). The legal emission limits for barium carbonate, at these production sites, vary locally and are given below:

Honningen, Germany:

Dust to air: 20 to 50 mg/m^3

Waste water: 5 mg/L (as barium)

Massa, Italy:

Dust to air: 20 to 150 mg/m^3

No waste water emission limit for barium

Onsan, Korea:

Dust to air: 120 mg/m^3

No waste water emission limit for barium

Monterrey, Mexico:

Dust to air: 220 to 660 mg/m^3

No waste water emission limit for barium

Kalahasti, India:

Dust to air: 115 mg/m^3

No waste water goes outside the plant (30)

There is no evidence that barium carbonate undergoes environmental biotransformation other than dissolving to a divalent cation. Photodegradation and biodegradation are not relevant transformation processes. Under natural conditions barium will form compounds in the +2 oxidation state. Barium does not hydrolyze appreciably except in highly alkaline environments. Environmental fate modelling cannot be performed with the available data.

Soil adsorption of barium was studied in a sandy soil and a sandy loam soil. Sludge solutions appeared to increase the mobility of elements in soil (9).

Absorption of a barium radioactive isotope by green algae was studied. After 15 days of exposure, absorption of $133Ba^{2+}$ in algae was 30 - 58 % of the added barium at a concentration in the test medium of 0.04 to 4.0 µg/L. Barium absorption in algae increased proportionally with decreasing medium concentration (13).

The bioconcentration factor for barium salt in bluegills was studied. The BCF value for *Lepomis macrochirus* in male carcass was 74.4 (µg/g wet weight of bluegill tissue)/(µg/mL unfiltered water) so barium salt has a low potential for bioaccumulation (46).

2.3 Human Exposure

The general population is commonly exposed to barium primarily through ingestion of drinking water and consumption of food and beverages (1).

Human exposure to barium carbonate may also occur during production or use in various industries, or as a result of accidental or intentional ingestion of rodenticide containing barium carbonate.

2.3.1 Occupational Exposure

In the production and processing facilities, workers might be exposed to barium carbonate dust by inhalation during handling of raw materials (barium carbonate), e.g. mixing or packaging processes.

In the production facilities, dust might be released to the air from loading silos, granulation, packaging and shipping processes. Since the packaging process is an open and manual system, workers have higher potential risk. They were provided with the appropriate PPE (Personal Protective Equipment) such as dust masks, and workplaces are managed by safe work practices.

In the processing facilities, workers can be exposed to barium carbonate dust during handling of raw materials (barium carbonate) or during mixing processes. The following controls are being applied to reduce employees exposure: engineering controls such as local ventilation systems;

administration controls such as regulation of industrial safety and health and safe work practices within a company; and the use of PPE such as dust masks, gloves, and aprons. Monitoring data from glass manufacturing factories indicated air concentration levels of dust for workplace were less than 0.4 mg/m^3, which is below the Korean permissible exposure limit of 10 mg/m^3. In addition, airborne barium concentrations from 0.0002 to 0.0004 mg/m^3 were recorded, which is below the American Conference of Governmental Industrial Hygienists threshold limit value (0.5 mg Ba/m^3). The periodical medical examinations showed no adverse health effect that could be attributed to barium carbonate (25).

2.3.2 Consumer Exposure

Available data are not specifically for barium carbonate, but for the barium cation.

Most of the drinking water in the USA was found to contain barium levels of < 0.2 mg/L although barium levels ranging from 1.0 to 10 mg/L have been detected. The latter high levels of barium were thought to be naturally occurring. The community water is supplied from deep rock and drift wells in northeastern Illinois so the exceeding levels of barium concentrations in groundwater supplies may be due to leaching and erosion of barium from sedimentary rocks (7, 21).

The concentration of barium in seawater varies greatly among different oceans and with latitude and depth. Within a given ocean barium concentration increases with the depth of water. Measured concentration of barium in seawater ranged from 0.04 - 37 mg/L (46).

Concentration of barium in seawater was 6 μg/L and 7 - 15,000 μg/L in fresh water (average 50 μg/L). Environmental exposure may result from food, drinking water and seawater (31).

Ambient barium concentrations ranged from 0.0015 to 0.95 μg/m^3 of air in a USA survey. Barium concentrations ranging from < 0.005 to 1.5 μg/m^3 of air have also been detected in 18 cities and 4 suburban areas in the USA (38, 43).

The background level of barium in soil is considered to range from 100 to 3,000 mg/kg with an average of 500 mg/kg (46).

Barium content in milk was found to range between 45 and 136 μg/g and in edible crops ranges from 10 μg/g in wheat to 3 - 4 mg/g in brazil nuts (15).

Assessment of potential health hazards for barium leached from glazed ceramic ware was studied. The oral RfD for barium as estimated by the EPA is 0.07 mg/kg/day and for a 70 kg adult, this represents a daily dose of 4.9 mg/person/day. Consumers of coffee, and coffee and orange juice at the 99th percentile level exceed the RfD with intakes of 6.2 and 5.6 mg/person/day, respectively. Also tea drinkers within the 99th percentile are ingesting barium levels comparable to the EPA RfD of 4.9 mg/day. The results of this preliminary assessment indicate further study is warranted. Analysis of a broad sample of commercial ceramic ware and study of barium leaching behaviour under actual conditions are needed to assess the significance of these findings.

In the sponsor country, barium carbonate is also used as glaze additives in ceramic ware. The content of barium carbonate is 1 – 2 % in glaze additives and the total use volume was below 10 tonnes/year in 2002. So consumer exposure for barium carbonate is estimated to be low in Korea (25).

3 HUMAN HEALTH HAZARDS

3.1 Effects on Human Health

The toxicity of barium compounds depends on their solubility. Barium carbonate is less soluble than barium chloride. Since the toxicity of Barium salts are mainly depending on the Barium ion, Barium carbonate is less toxic than barium chloride. So in nearly all sections the studies of barium chloride are used as a surrogate to estimate the toxicity of barium carbonate.

3.1.1 Toxicokinetics, Metabolism and Distribution

Studies in Laboratory Animals

Rats (*ad lib* fed) maintained on a basal diet of less than 1 mg barium/kg food for one month were administered radio-labeled ^{131}barium carbonate (5 µg/100 g bodyweight) by intubation. Absorption and distribution were fairly rapid; peak radioactivity levels in blood and eyes were measured 60 minutes after dosing (22). Following administration of ^{131}barium chloride (5 µg/100 g bodyweight), blood levels of radioactivity were maximal at 15 minutes (fasted rats) or 60 minutes (*ad lib* fed rats). Eye radioactivity levels were twice those of blood levels within 2 hours of administration. Radioactivity levels after 24-hours of ^{131}barium chloride administration were in the order of heart (2.05) > eye (0.70) > skeletal muscle (0.64) > kidney (0.50) > blood (0.25) > liver (0.18). The units of the parenthesized values are (CPM/g tissue)/(CPM administered/g body weight). These results indicated that barium was concentrated in some tissues compared to blood. Absorption of barium chloride was faster in fasted animals. The data also showed similarity in absorption and distribution of the two salts of barium; albeit that the carbonate salt was less extensively absorbed. Peak levels of ^{131}barium carbonate measured at 60 minutes (last sample time) were 40 – 50 % of the radioactivity levels following administration of ^{131}barium chloride.

Both blood and eye radioactivity levels following administration of ^{131}barium chloride were twice the levels observed following ^{131}barium carbonate administration. The distribution and long-term retention of barium was investigated in rats by intra-muscular injection with ^{133}barium as chloride, carbonate, sulfate salts or fused clay (41). Following administration, scanning data showed the level of whole body radioactivity decreased tri-exponentially for the chloride and carbonate, bi-exponentially for the sulfate and fused clay remained almost constant. Loss of radioactivity was similar for the two most soluble salts, chloride and carbonate salt, and absorption was also most rapid; within 5 days greater than 50 % of the dose was cleared. Thereafter the rate of loss declined and by day 280 approximately 20 % of the initial dose was still present. After about 100 days the chloride, carbonate and sulfate forms of ^{133}barium behaved similarly. When the rats died or at the study end (between 55 and 399 days) the femurs, humeri, injection site and carcass were quantified for radioactivity. ^{133}Barium was localized primarily in the bones and had a biological half-life of 460 days.

Studies in Humans

Barium is not an essential element in human tissue. The metabolism of barium in mammals has been studied with radioactive isotopes and shown to be essentially similar to calcium and strontium (42). The principal physiological activity of barium is stimulation of all types of muscle, irrespective of their innervations. Mammalian intestinal mucosa is highly permeable to barium ions and is involved in the rapid flow of soluble barium salts into and out of the blood. However, absorption of naturally occurring barium in food is only about 2 % of total dietary intake, because it occurs in bound or insoluble forms. The average daily human intake of barium is about 1.3 mg (0.65 – 1.7 mg). The human adult body contains 22 mg of barium of which 66 % is present in bones. Analysis of human tissues reveals the presence of barium in the following: adrenal, aorta, thyroid, lung, muscle, testes, ovary, uterus and urinary bladder, indicating wide distribution in soft tissues. Mammalian eye contains barium in the iris in concentrations varying from 206 to 1,110 µg/g wet tissue. The majority of barium (65 %) is deposited into bones and estimated to have a half-life of 50 days (11).

Excretion of barium is both fecal and urinary, depending upon route of entry. Within 24 hours, 20 % of an ingested dose appears in feces (indicating enterohepatic circulation) and 5 – 7 % is excreted in the urine (42). Injection of a soluble barium salt, results in increased urinary excretion, compared to an ingested dose, but fecal excretion is still greater. Within 21 days, 90 % of the dose is excreted in a 1:9 ratio of urine:feces (12). Except in the lungs and aorta, there is no total accumulation of barium with human age. Barium is found in newborn babies at concentrations higher than in adults; it crosses the mammary and placental barriers (42).

Conclusion

In rat studies, barium carbonate distribution has been shown to be similar to that for barium chloride although it is not absorbed to the same extent. Barium is widely distributed; concentrates in some organs compared to blood. The data indicate long-term retention of barium is due to distribution within the bones. The human adult body contains 22 mg of barium of which 66 % is present in bones and estimated to have a half-life of 50 days. Trace quantities are found in various tissues. Barium is mainly eliminated in feces.

3.1.2 Acute Toxicity

Studies in Laboratory Animals

The LD_{50} of barium carbonate in rats and mice was 418 and 200 mg/kg bw, respectively (26).

The acute oral LD_{50} of barium chloride, administered as a solution, to Sprague-Dawley rats was 419 (males) and 408 (females) mg/kg bw (4). Ninety percent of deaths occurred within 5 hours of administration, and hemorrhagic areas in the stomach and inflammation on the intestines showed in primary necropsy. Groups of 10 male and 10 female rats received barium chloride for one single day at doses of 0, 30, 100, and 300 mg/kg bw (4). At 300 mg/kg bw, 8 of 10 male and 7 of 10 female rats died within 24 hours, and inflammation of the small and large intestines were seen at the 300 mg/kg bw dose level in both sexes. The effects on body, liver, and kidney weights in 300 mg/kg bw group appear to be related to barium chloride.

A number of studies have been performed in dogs administered barium chloride infusions intravenously (33). The collective data showed that infusion of barium chloride (doses varied within and between experiments; total range 0.36 – 2.0 µmol/kg/min infused over 20 – 100 minutes) in dogs caused a decrease in plasma potassium concentration and an increase in red cell potassium concentration. There was no increased urinary excretion of potassium. The hypokalaemia was a result of potassium shift from extracellular to intracellular fluid. Myocardial toxicity due to barium chloride was observed and this was effectively abolished by infusion of potassium chloride. Arterial hypertension was also observed and was thought to occur as a result of direct effect on the arterial smooth muscle. The hypertension was not prevented or altered by prior or simultaneous infusion of potassium chloride.

In an intra-tracheal study (presumed to be in rats), 50 mg of barium carbonate dust was administered followed by a 9-month post exposure period (39). At 3 months there were early signs of sclerosis [hardening] in the lung with no accumulation of barium carbonate. At 6 months, lung tissue showed pronounced sclerosis and by 9 months the sclerosis was even more pronounced. Fibrous pneumonia with necrosis of the large bronchi mucous membrane was also developed.

There were no reliable animal acute toxicity studies by dermal and inhalation routes available.

Studies in Humans

There were various reported cases of barium carbonate poisoning in humans due to accidental ingestion as food (18), intentional ingestion in suicide cases (34) and accidental exposure at work (35). In all cases the symptoms presented and clinical treatment are the same. Barium initially stimulates striated, cardiac and smooth muscle and depresses serum potassium, which is forced intracellularly. Subsequent muscle weakness may result from a direct depolarizing effect and neuromuscular blockade. Symptoms are vomiting, severe abdominal pain, diarrhea, slow irregular pulse, muscle paralysis, dilated pupils, increasing somnolence, cardiac arrest.

Conclusion

The LD_{50} of barium chloride in rats was 419 (males) and 408 (females) mg/kg bw. The barium chloride studies in dogs demonstrated the toxicity of barium, which is relevant to barium carbonate. The barium infusion caused a reduction in plasma potassium resulting in hypokalaemia and also caused hypertension.

3.1.3 Irritation

The available results from irritation studies were all from a publication lacking information on methodology. Sub-acute experiments in rats and rabbits demonstrated local irritant effects of barium carbonate on the skin and mucous membranes (39). In particular, barium carbonate in a lanolin base applied to rat or rabbit skin caused the development of small ulcers. These disappeared within one month once treatment was discontinued. Barium carbonate introduced to the conjunctival sac produced purulent discharge, followed by conjunctivitis and slight corneal opacity.

Conclusion

No reliable skin/eye irritation sty results are available. Based on results from a publication lacking information on methodology, barium carbonate could be considered a skin and eye irritant.

3.1.4 Sensitization

There are no sensitization studies available.

3.1.5 Repeated Dose Toxicity

Short-term oral exposure (10 days) to barium chloride produced compound related effects (4). One male rat and 3 female rats died in the 209 and 300 mg/kg bw/day dose groups, respectively. There was a significant decrease of ovary weight (0.11 ± 0.01 g) compared to the controls (0.14 ± 0.01 g) and blood urea nitrogen at 300 mg/kg bw/day.

Barium chloride dihydrate was given to F334/N rats and B6C3F1 mice in drinking water for 13 weeks at concentrations of 0, 125, 500, 1,000, 2,000, and 4,000 ppm, corresponding to an average daily dose of 0, 10, 30, 65, 110, and 200 mg Ba/kg bw to male rats, 0, 10, 35, 65, 115, and 180 mg Ba/kg bw to female rats, 0, 15, 55, 100, 205, and 450 mg Ba/kg bw to male mice and 0, 15, 60, 110, 200, and 495 mg Ba/kg bw to female mice, respectively (27). In rats, three males and one female died at the dose of 4,000 ppm. The final mean body weights, mean body weight gains, and water consumption were lower than the controls in the 4,000 ppm dose groups. Renal tubule dilatation in the outer medulla and the renal cortex occurred in all rats exposed to 4,000 ppm, which was a chemical-induced kidney lesion. In mice, six males and seven females died in the 4,000 ppm groups. The final mean body weights and water consumption were significantly lower than those of the controls. Also, nephropathy – tubule dilatation, regeneration, and atrophy – and atrophy of the thymus and spleen were observed in male and female mice receiving 4,000 ppm.

A similar study was conducted in the same species with the same concentration of barium chloride dihydrate in drinking water for 92 days (8). The daily barium dose levels were the following: 0, 4.3, 17.0, 32.9, 61.1, and 120.7 mg Ba/kg bw to male rats; 0, 5.8, 23.3, 45.4, 80.9, and 136.4 mg Ba/kg bw to female rats; 0, 12.4, 41.9, 82.9, 164.7, 436.2 mg Ba/kg bw to male mice; and 0, 11.5, 48.0, 83.0, 165.8, and 562.0 mg Ba/kg bw to female mice. In rats, 3 of 10 males and 1 of 10 females in the 4,000 ppm groups died. Body weights of both sexes in the 4,000 ppm groups were significantly ($p < 0.05$) lower than the controls. Treatment-related lesions associated with the barium chloride toxicity were present in the kidneys of rats which received 4,000 ppm. In mice, 6 of 10 males and 7 of 10 females in the 4,000 ppm groups died. Body weights of both sexes in the 4,000 ppm groups were significantly ($p < 0.05$) lower than the controls. The liver weights of mice which received 2,000 ppm or greater were depressed. The absolute kidney weights were elevated in the high dose mice, and the relative kidney weights were elevated in the 4,000 ppm mice. Thymus weights were depressed in the high dose mice. Renal lesions in mice were much more severe than those of rats.

No oral repeated dose studies with barium carbonate were available.

The studies summarized below were all within a publication (39) lacking in detailed methodology and were therefore not considered for the initial assessment.

A one-month inhalation study in albino rats exposed to 33.4 ± 3.6 mg/m^3 barium carbonate dust revealed signs of toxicity (39). There was no data on strain of species, number per group, duration or frequency of dosing or method of exposure available. Changes were noted in red and white blood cells, and there was inhibition of enzymes and hepatic activity. Pathomorphological examination revealed desquamative bronchitis in the bronchi and focal thickening of the interalveolar septa in lung tissue. There were signs of granular dystrophy in the heart, liver and kidney.

The same publication also reported the findings for a 4-month inhalation exposure of rats to 5.2 ± 0.25 and 1.15 ± 0.15 mg/m^3 for 6 days a week, four hours a day. There were no data on strain or numbers per group and statistical method. A control group was included, and exposed to pure air. Following 4-month exposure, general toxicity was observed in the high dose group: arterial pressure was increased; cholinesterase levels were reduced; and liver function showed impaired detoxifying function. The heart, liver and kidneys showed signs of mild granular dystrophy. In the lungs, there were signs of moderate perivascular and peribronchial sclerosis (hardening) with focal thickening of the interalveolar septa and collagenation. The changes remained at the end of the (unspecified) recovery time. Exposure to 1.15 ± 0.15 mg/m^3 barium carbonate dust produced virtually no toxicity.

Conclusion

The NOAEL was estimated to approximately 2,000 ppm (corresponding to the average daily dose of 110 and 115 mg Ba/kg bw to male and female rats, respectively, and 205 and 200 mg Ba/kg bw to male and female mice, respectively) based on mortality, renal toxicity, decreases of the final mean body weights, mean body weight gains and water consumption.

The NOAEL of the similar study was 2,000 ppm (rats: 61 - 81 mg Ba/kg bw/day, mice: 165 - 166 mg Ba/kg bw/day) in the drinking water based on depressed body weight gains and chemically related lesions in the kidney and lymphoid tissue.

3.1.6 Mutagenicity

There were no *in vitro* or *in vivo* genotoxicity studies of barium carbonate available. But *in vitro* genetic toxicity tests with barium chloride were reported (27). The studies on barium chloride dihydrate were of a high quality.

A bacterial reverse mutation assay (Ames test) was performed . Barium chloride dihydrate (up to 10 mg/plate) did not induce gene mutations in any of five strains of *Salmonella typhimurium* (TA97, TA98, TA100, TA1535, and TA1537) with or without metabolic activation systems (S9).

Mutagenicity of barium chloride dihydrate was also tested in cultured mammalian cells (mouse lymphoma mutagenicity and chinese hamster ovary cell cytogenetics). At concentrations of 250 µg/mL and above, barium chloride induced gene mutations at the TK $^{+/-}$ locus of L5178Y mouse lymphoma cells in the presence of Aroclor1254-induced male Fisher 344 rat liver S9 mix. Without S9, no increase in the number of mutant colonies was observed. *In vitro* tests in Chinese hamster ovary (CHO) cells showed that barium chloride dihydrate did not induce chromosome changes up to the concentration of 3,000 µg/mL for sister chromatid exchanges and 5,000 µg/mL for chromosome aberrations with or without S9 mix.

No *in vivo* study of barium chloride dihydrate was available.

Conclusion

All, except one *in vitro* genotoxicity study were negative. The mouse lymphoma test gave an equivocal result only in the presence of an S9 activation system.

3.1.7 Carcinogenicity

There were no carcinogenicity studies of barium carbonate available. However, carcinogenicity of barium chloride dihydrate was examined in 60 rats (F334/N) and 60 mice (B6C3F1) of each sex (27). Animals were exposed to the test substance at a concentration of 0, 500, 1,250, and 2,500 ppm in drinking water for 2 years, corresponding to the average daily dose of up to 60 and 75 mg Ba/kg bw/day in male and female rats, respectively, and 160 and 200 mg Ba/kg bw/day in male and female mice, respectively. In rats, there was no treatment-related effect on survival. Barium levels in plasma and bone were significantly increased in the high dose groups compared to the controls. No incidence of neoplasms or non-neoplastic lesions were observed, but there was dose-related decreased incidences of adrenal medulla pheochromocytomas and mononuclear cell leukemia in male rats. In mice, survival and final body weights of each sex receiving 2,500 ppm was significantly lower than those of the controls. There were no increased incidences of neoplasms. The incidences of nephropathy and lymphoid depletion were increased in 2,500 ppm male and female groups. Also, the relative and absolute spleen weights were lower than the controls.

Conclusion

There was no evidence of carcinogenic activity (showing no chemical-related increase of malignant or benign neoplasms) of barium chloride dihydrate in either sex of rats or mice that received up to 2,500 ppm by oral route.

3.1.8 Reproductive Toxicity

Effects on Fertility

Groups of 20 male and 20 female rats received barium chloride dihydrate in drinking water at concentrations of 0, 1,000, 2,000, and 4,000 ppm (corresponding to 0, 63.5, 112, and 201.5 mg

Ba/kg bw/day to males and 0, 64.5, 114, and 179.5 mg Ba/kg bw/day to females). Groups of 20 male and 20 female mice received barium chloride dihydrate in drinking water at concentrations of 0, 500, 1,000, and 2,000 ppm (corresponding to 0, 52.9, 102.5, and 206 mg Ba/kg bw/day to males and 0, 58.9, 105.2, and 199.8 mg Ba/kg bw/day to females) (8). The average daily doses put in parentheses were calcuated from those of the 92 days study. The pre-mating exposure period was 60 days and 30 days to males and females, respectively. The results of the controls and the high dose groups were available in each species. The pregnancy rates to rats were 40 % in the controls and 65 % in the 4,000 ppm group, which is below the accepted norm. This problem was not corrected by remating due to restriction in the study dosing schedule/design. The average gestation period of dams was 22 to 22.5 days. The number of implants per pregnant dam in the 4,000 ppm group (7.7 ± 0.52) was marginally lower than the controls (9.6 ± 1.10). In mice, there was no evidence of maternal weight gain during pregnancy compared with the controls.

No treatment-related effects of barium chloride dihydrate observed in epididymal sperm count, sperm motility, sperm morphology, testis or epididymal weight, or vaginal cytology in each species up to the maximum concentrations. The NOAEL was determined to be 4,000 ppm in rats and 2,000 ppm in mice based on these results.

The fertility studies summarized below were all within a publication (39) lacking in detailed methodology and were therefore not considered for the initial assessment.

Female rats exposed by inhalation to barium carbonate dust (13.4 ± 0.7 and 3.1 ± 0.16 mg/m^3) for 4 months (probably for 4 hours/day on 6 days/week) had a shortened estrous cycle at the higher exposure concentration. There were morphological changes noted in the ovary structure and the proportion of mature and dying follicles was altered. Females of the high exposure group gave birth to underdeveloped offspring, which showed high mortality and slower increase in body weight during the first two months compared to the control. Also, the 2-months old rats exhibited decreased lability of the peripheral nervous system and blood disorders (erythropenia, leukocytosis, eosinophilia, neutrophilia).

Following inhalation exposure to male rats of barium carbonate dust (22.6 ± 0.6 mg/m^3) for one cycle of spermatogenesis there was a decrease in total number of spermatozoids, in percentage of mobile forms, motility time and in spermatozoid osmotic resistance. Similar changes such as the disturbance of spermatogenesis and sperm motility were observed in male rats exposed for 4 months to 5.2 ± 0.25 mg/m^3 of barium carbonate dust. The embryonic mortality was increased three-fold in female rats mated with males exposed to barium carbonate at 5.2 ± 0.25 mg/m^3. The female rats were probably untreated. The viability of the offspring was lower than the control; 51.3 % of the young died within 60 days, compared to 24.4 % of the control group. There were no malformations of the internal organs in the offspring.

Developmental Toxicity

The same study was given as reported on the fertility toxicity (exposure of barium chloride dihydrate to rats and mice via drinking water (8)). In rats, no significant decreases were observed in the average live litter size on day 0 and 5, the number of implants per pregnant dam, and pup weight on day 5 in the 4,000 ppm groups. Rats receiving 4,000 ppm exhibited marginal reductions in pup weight on day 1. No external abnormalities were observed. In mice, a statistical significance was observed in the average live litter size on day 0 and 5 in the 1,000 ppm dose group, but there were no changes in the 2,000 ppm dose group. No external anomalies were noted in any of the offspring, and there were no statistical differences in live pup weights. The NOAEL for developmental toxicity was 4,000 ppm and 2,000 ppm in rats and mice, respectively.

The following study had a limited methodology and was therefore not considered for the initial assessment. Oral administration of 1/16th of the LD_{50} (value not reported) to female rats for 24 days before conception and during the entire pregnancy caused an increased offspring mortality rate for a period of 2 months after birth (39). Blood leukocyte count in the offspring was increased and a disturbance of hepatic activity was indicated by increased excretion of hippuric acid in the urine.

Conclusion

The NOAEL for barium chloride dihydrate on fertility and developmental toxicity was 4,000 ppm in rats (male: 201.5 mg Ba/kg bw/day, females: 179.5 mg Ba/kg bw/day) and 2,000 ppm in mice (male: 206 mg Ba/kg bw/day, females: 199.8 mg Ba/kg bw/day).

3.2 Initial Assessment for Human Health

Barium carbonate has been shown to be absorbed fairly rapidly following oral administration, and is widely distributed within the body with long-term retention in bones. The long-term retention demonstrated in animal studies has also been shown in humans, although the half-life is shorter (50 days). Barium has been shown to cross the placental and mammary barriers. The acute oral LD_{50} of barium chloride to rats was 419 (males) and 408 mg/kg bw (females) indicating hemorrhage and inflammation in digestive organs. The NOAEL for barium chloride dihydrate in drinking water on repeated dose toxicity was 2,000 ppm, corresponding to the doses of 61 – 115 mg Ba/kg bw to rats and 165 – 200 mg Ba/kg bw to mice (based on differences in sex and age). This was based on mortality, decreased final mean body weights and mean body weight gains, decreased water consumption and renal toxicity. Barium chloride dihydrate was negative in *in vitro* genotoxicity studies except for the an equivocal result in a mouse lymphoma test with S9 mix at 250 ug/mL and above. There was no evidence of carcinogenic activity of barium chloride dihydrate in either sex of rats or mice that received up to 2,500 ppm in drinking water. The calculated NOAEL for fertility and developmental toxicity for exposure to barium chloride dihydrate in drinking water was 4,000 ppm in rats (male: 201.5 mg Ba/kg bw/day, females: 179.5 mg Ba/kg bw/day) and 2,000 ppm in mice (male: 206 mg Ba/kg bw/day, females: 199.8 mg Ba/kg bw/day).

4 HAZARDS TO THE ENVIRONMENT

4.1 Aquatic Effects

Aquatic toxicity studies for barium carbonate as well as for other barium salts studies were assessed. Water solubility of different barium compounds are as follows.; barium chloride; 375 mg/L at 26 °C; barium sulfate; 0.002 mg/L (46). The following acute and chronic toxicity tests with aquatic organisms are available.

Table 4.1 Effects of barium compounds on aquatic organisms

Organisms	Test substance	Species	Results	Test condition	Ref.
Fish	Barium carbonate	*Gambusia affinis*	TLm (96 h) > 10,000 mg/L	I. E. Wallen *et al*, 1957 static, nominal concentration	(44)
	Barium (salt not given)	*Cyprinodon variegatus*	LC_{50} (96 h) > 500 mg/L	"Methods for acute toxicity tests with fish, macroinvertebrates and amphibians" U.S. EPA 1975.	(14)
	Barium (salt not given)	rainbow trout, embryos and larvae	LC_{10}(4 days)= 9.5 mg/L	Birge, W.J., Black, J.A. and Ramsey. B.A., 1981, Static renewal	(3)
	Barium chloride dihydrate	*Austropotamo bius pallipes pallipes*	LC_{50} (30 days)= 39 mg/L	The American Public Health Association, Flow through	(46)
		Orconectes limosus	LC_{50} (30 days)= 59 mg/L	The American Public Health Association, Flow through	(46)
Invertebrate	Barium (salt not given)	*Daphnia magna*	NOEC (48 h) = 68 mg/L LC_{50} (48 h) = 410 mg/L	Methods for Acute Toxicity Tests with Fish, Macroinvertebrates, and Amphibians (US EPA, 1975) (static, nominal concentration)	(20)
	Barium sulfate	*Daphnia magna*	EC_{50} (48 h) = 32 mg/L	B.S.Khangarot et al,1989 (static, nominal concentration)	(5)
	Barium chloride dihydrate	*Daphnia magna*	EC_{50} (48 h) = 14.5 mg/L	K.E.Biesinger et al,1972 (static, nominal concentration)	(2)
	Barium chloride dihydrate	*Daphnia magna*	EC_{50} (21 days)=13.5 mg/L	K.E.Biesinger et al,1972 (static, nominal concentration)	(2)
Aquatic plant	Barium chloride dihydrate	*Lemna minor*	IC_{50} (96 h) > 102-400 mg/L	Wang, W., 1986 Growth rate, nominal concentration)	(45)

A median tolerance limit (TLm) of > 10,000 mg/L barium carbonate was determined in *Gambusia affinis* at 24, 48, and 96 hours. Although 2 fish died, they did not show any symptoms of poisoning (45).

Barium (salt not given) LC_{50} was determined in *Cyprinodon variegates* (sheepshead minnows) to be > 500 mg/L at 24, 48, 72, and 96 hours. The no effect concentration was 500 mg/L (14).

The LC_{50} of barium (salt not given) to the water flea (*Daphnia magna*) was > 530 mg/L at 24 hours and 410 mg/L at 48 hours. 48 hr-EC_{50} acute toxicity of insoluble barium salt, barium sulfate, was 32 mg/L and 48 hr-LC_{50} of soluble barium salt, barium chloride dihydrate was 14.5 mg/L (5, 20, 2).

Barium (as chloride) phytotoxicity to the common duckweed (*Lemna minor*) was tested in various water samples. A total of 59 water samples from 18 different locations, encompassing lake and stream waters with a wide variation in water quality, were collected. Ten sites were in the state of Illinois and the remaining eight in neighboring states. The results showed that barium toxicity to the common duckweed was highly dependent on site-specific water quality. The barium ion was most toxic to the common duckweed from Hayes Creek and Horseshoe Lake, with 50 % growth inhibition (IC_{50}) at concentrations of 102 and 107 mg/L barium and least toxic in Beaucoup Creek, with 0 – 6 % growth inhibition at 400 mg/L. The major factor modifying barium toxicity was the sulfate concentration in the water samples. A linear relationship with a coefficient of determination of 0.68 (n = 39) confirmed that barium toxicity was modified by sulfate content (45).

Chronic toxicity to fish was studied. In a static renewal test using rainbow trout embryos and larvae, 4 days LC_{10} and LC_1 values for barium (salt not specified) of 9.5 and 2.8 mg/L were determined (3). 30 days LC_{50} values of *Orconectes limosus* and *Austropotamobius pallipes pallipes* (crayfish) for barium chloride were 59 mg/L and 39 mg/L, respectively. 21 days LC_{50} value of *Daphnia magna* for barium chloride was 13.5 mg/L (46).

Barium carbonate is absorbed to a lesser extent than barium chloride or barium sulfate so the toxic effect of barium carbonate is overestimated when using results from barium chloride or sulfate.

4.2 Terrestrial Effects

Barium carbonate added to ground wheat germ at 1.5, 3.0, and 6.0 % elicited a toxic response in mites fed on the diet. At 6.0 % barium carbonate, female egg production was completely inhibited and mite mortality was 25 % and 90 % at 7 and 17 days, respectively (17).

4.3 Other Environmental Effects

There are no other environmental effect studies available.

4.4 Initial Assessment for the Environment.

Barium carbonate slightly soluble in water and due to its inorganic properties no data are available for vapour pressure and partition coefficient in n-octanol/water. Photodegradation, biodegradation are not relevant transformation processes. Under natural conditions barium will form compounds in the +2 oxidation state. Barium does not hydrolyze appreciably except in highly alkaline environments. Environmental fate modelling cannot be performed with the available data. Barium absorption in algae increased proportionally with decreasing barium concentration in the medium. Based on a BCF value of 74.4 in fish, barium has a low potential for bioaccumulation.

The following acute toxicity tests with aquatic organisms are available:

Barium carbonate; *Gambusia affinis*: TLm (96 h) > 10,000 mg/L

Barium sulfate; *Daphnia magna*: EC_{50} (48 h) = 32 mg/L

Barium chloride dihydrate: *Lemna minor*; lC_{r50} (96 h) = 102 - 400 mg/L

5 RECOMMENDATIONS

The chemical is currently of low priority for further work. The chemical possesses properties indicating a hazard for human health and the environment. These hazards do not warrant further work as they are related to acute toxicity which may become evident only at high exposure level. They should nevertheless be noted by chemical safety professionals and users.

6 REFERENCES

(1) Agency for Toxic Substance and Disease Registry U.S. Public Health Service, "Toxicological Profile for Barium and Compounds", July, 1992

(2) Biesinger, K.E. and Christensen, G.M., 1972. J. Fish. Res. Board Can. Vol 29, 1691 – 1700

(3) Birge, W.J., Black, J.A. and Ramsey. B.A., 1981. The Reproductive Toxicology of Aquatic Contaminants. Hazard Assessment of Chemicals: Current Developments, Vol 1, 59 – 115

(4) Borzelleca, J.F., Condie Jr., L.W. and Egle Jr. J.L., 1988. Short-term Toxicity (One- and Ten-Day Gavage) of Barium Chloride in Male and Female Rats. J. American College of Toxicol., Vol 7, 675 – 685

(5) B.S.Khangarot and P.K.Ray, "Investigation of Correlation Between Physicochemical Properties of Metals and Their Toxicity to the Water Flea Daphnia magna Straus", Ecotoxicology and Environmental Safety 18, pp. 109 – 120, 1989

(6) Budavari, S., O'Neil, M., Smith, A., Heckelman and Kinneary, J. The Merck Index, An Encyclopedia of Chemicals, Drugs and Biologicals, 12th Edition on CD-ROM Version 12:2, Chapman & Hall /CRC

(7) Calabrese E.J., 1977. Excessive Barium and Radium-226 in Illinois Drinking Water. J. Environ. Health, Vol 39 (5), 366 – 369

(8) Dietz. D.D, M.R. Elwell, W.E. Davis, Jr., and E.F. Meirhenry, 1992, Subchronic Toxicity of Barium Chloride Dihydrate Administered to Rats and Mice in the Drinking Water, Fundamental and Applied Toxicology, 19, 527 – 537

(9) Gerritse, R.G., Vriesema, R., Dalenberg, J.W., and De Roos, H.P. 1982, Effect of Sewage Sludge on Trace Element Mobility in Soils. J. Environ. Qual. Vol 11, 359 – 364

(10) Gosselin, R.E., Smith, R.P. and Hodge, R.C., 1984. Section III. Therapeutic Index in Clinical Toxicology of Commercial Products, Fifth edition, Baltimore: Williams and Wilkins

(11) Handbook on the Toxicity of Inorganic Compound, 1988, page 99

(12) Harrison, G.E., Carr, T.E.F. and Sutton, A., 1967. Distribution of Radioactive Calcium, Strontium, Barium and Radium Following Intravenous Injection into a Healthy Man. Int. J. Radiat. Biol., Vol 13, 235 – 247

(13) Havlik, H., Hanusova, J. and Ralkova, J., 1980. Hygienic Importance of Increased Barium Content In Some Fresh Waters. J. Hyg., Epidemiol., Microbio. and Immun., Vol 24, 396 – 404

(14) Heitmuller, P.T., Hollister, T.A. and Parrish, P.R., 1981. Acute Toxicity of 54 Industrial Chemicals to Sheepshead Minnow (Cyprinodon variegatus). Bull. Environ. Contam. Toxicol., Vol 27, 596 – 604

(15) http://ecb.jrc.it/, The European Chemicals Bureau (ECB), IUCLID, Year 2000 CD-ROM edition, 2004

(16) http://minerals.usgs.gov/minerals/pubs/commodity/barite/080498.pdf

(17) Igantowicz, S., 1983. Effect of Inorganic Salts upon the Biology and Development of Acrid Mites. 1. Effect of Mineral Salts on Fecundity and Egg Viability of 'Copra Mite' Tyrophagus Putrescentiae (Schrank) (Acarina: Acaridae). Zeszyty Problemowe Postepow Nauk Rolniczych, Vol 252, 207 – 229

(18) Johnson, C.H. and Van Tassell, V.J., 1991. Acute Barium Poisoning With Respiratory Failure and Rhabdomyolysis. Ann. Emerg. Med., Vol 20, 1138 – 1142

(19) Kirk-Othmer Encyclopedia of Chemical Technology, Fourth Edition, Vol 3. Published by John Wiley and Sons, 1991

(20) LeBlanc, G.A., 1980. Acute Toxicity of Priority Pollutants to Water Flea (Daphnia Magna). Bull. Environ. Contam.Toxicol., Vol 24, 684 – 691

(21) Letkiewicz F, Spooner C, Macaluso C, Borum D., 1984.Occurrence of Barium in Drinking Water, Food and Air. Prepared by JRB Associates, McLean, VA, for the Office of Drinking Water, US Environmental Protection Agency

(22) McCauley, P.T. and Washington, I.S., 1983. Barium Bioavailability as the Chloride, Sulfate or Carbonate Salt in the Rat. Drug and Chem. Toxicol., Vol 6, 209 – 217

(23) Metals and Related Compounds, Chapter 37, p 1017, 1988. In Medical Toxicology - Diagnosis and Treatment of Human Poisoning

(24) National Chemical Inventories™ 2002 Issue 1, CAS Surveyor, American Chemical Society

(25) National Institute of Environmental Research (NIER), Korea, Survey on circulation volume and use pattern of barium carbonate in Korea, 2004

(26) NIOSH, The Registry of Toxic Effects of Chemical Substances RTECS #: CQ8600000, 2004

(27) NTP(1994) NTP technical report on the toxicology and carcinogenesis of barium chloride dihydrate (CAS No. 10326-27-9) in F344/N rats and $B6C3F_1$ mice(drinking water studies). Research Triangle Park, NC, US Department of Health and Human Services, National Institute of Health, National Toxicology Program (Toxicity Report Series No. 432)

(28) Occupational Health Guideline for Soluble Barium Compounds (as Barium), Sept 1978, U.S. Department of Labor, Occupational Safety and Health Administration

(29) Ogen, S., Rosenbluth, M.D. and Eisenberg A., 1967. Food Poisoning due to Barium Carbonate in Sausage. Israel J. Med. Sci., Vol 3, 565 – 568

(30) Personal communication from Solvay, May 2004

(31) Reeves A.L., 1986. Handbook of Toxicology of Metals

(32) Richard, J. Lewis, Sr. SAX' Dangerous Properties of Industrial Materials on CD-ROM 10^{th} ed., John Wiley & Sons, Inc., New York, 2000

(33) Roza, O. and Berman, L.B., 1971. The Pathophysiology of Barium: Hypokalaemic and Cardiovascular Effects. J. Pharmacol. Exp. Ther., Vol 177, 433 – 439

(34) Schorn, Th. F., Olbricht, Ch., Schuler, A., Franz, A., Wittek, K., Balks, H.-J., Hausmann, E. and Wellhoener, H.-H., 1991. Barium Carbonate Intoxication. Intensive Care Med., Vol 17, 61 – 62

(35) Shankle, R. and Keane, J., 1988. Acute Paralysis from Inhaled Barium Carbonate. Arch Neurol, Vol 45, 579 – 580

(36) Solvay web site, July 2003,www.solvay-bariumstrontium.com/products

(37) Spin on The Internet, Substances in Preparations in Nordic Countries, http://www.spin2000.net/spin.html, 2004

(38) Tabor E.C. and Warren W.V., 1958. Distribution of Certain Metals in the Atmosphere of Some American Cities. Archives of Industrial Health, Vol 17, 145 – 151

(39) Tarasenko, N.Yu., Pronin, O.A. and Silayev, A.A., 1977. Barium compounds as Industrial Poisons (An Experimental Study). J. Hyg. Epidem. Microbio. Imm., Vol 21, 361 – 373

(40) Thienes, C. and Haley, T.J., 1972. Smooth Muscle Excitants and Depressants. Chapter 14, p 119, in Clinical Toxicology, Fifth Edition, Philadelphia: Lea and Febiger

(41) Thomas, R.G., Ewing, W.C., Catron, D.L. and McClellan, R.O., August 1973. In Vivo Solubility of Four Forms of Barium Determined by Scanning Techniques. Amer. Ind. Hyg. Ass. J. 350 – 359

(42) Toxicity of Group II Metals. Barium, p 63 – 65 in Metal Toxicity in Mammals, 1978, second edition

(43) US EPA, 1984. Health Effects Assessment for Barium. Prepared for the Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington DC.Cincinnati, OH, US Environmental Protection Agency, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office (EPA 540/1-86-021)

(44) Wallen, I.E., Greer, W.C. and Laster, R., 1957. Stream Pollution, Toxicity to Gambusia Affinis of Certain Pure Chemicals in Turbid Waters, Toxicity, Vol 29 (6), 695 – 711

(45) Wang, W., 1988. Site-Specific Barium Toxicity to Common Duckweed, Lemna Minor. Aquatic Toxicol., Vol 12, 203 – 212

(46) World Health Organization Geneva, 2001, Concise International Chemical Assessment Document 33, Barium and Barium Compounds

(47) www.epa.gov/triexplorer, 2004

S I D S

Dossier

Existing Chemical	:	ID: 513-77-9
CAS No.	:	513-77-9
EINECS Name	:	Barium carbonate
EC No.	:	208-167-3
TSCA Name	:	Carbonic acid, barium salt (1:1)
Molecular Formula	:	$BaCO_3$

Producer related part

Company	:	Solvay S.A.
Creation date	:	25.07.2003

Substance related part

Company	:	Solvay S.A.
Creation date	:	25.07.2003
Status	:	
Memo	:	
Printing date	:	01.06.2004
Revision date	:	
Date of last update	:	26.08.2005
Number of pages	:	
Chapter (profile)	:	Chapter: 1, 2, 3, 4, 5, 6
Reliability (profile)	:	Reliability: without reliability, 1, 2, 3, 4
Flags (profile)	:	Flags: without flag, confidential, non confidential, WGK (DE), TA-Luft (DE), Material Safety Dataset, Risk Assessment, Directive 67/548/EEC, SIDS

1.0.1 APPLICANT AND COMPANY INFORMATION

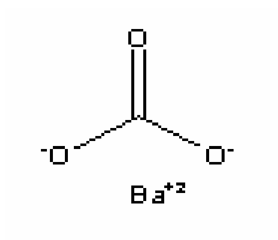
1.0.2 LOCATION OF PRODUCTION SITE, IMPORTER OR FORMULATOR

1.0.3 IDENTITY OF RECIPIENTS

1.0.4 DETAILS ON CATEGORY/TEMPLATE

1.1.0 SUBSTANCE IDENTIFICATION

CAS number : 513-77-9
IUPAC Name : Barium carbonate
Molecular formula : $BaCO_3$
Structural Formula :



Molecular weight : 197.34
Remark :

Molecular formula	Chemical name	CAS No.
$BaCl_2$	Barium chloride	10361-37-2
$BaCl_2 \cdot 2 H_2O$	Barium chloride dihydrate	10326-27-9
$Ba \cdot H_2SO_4$	Barium sulfate	7727-43-7

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

1.1.1 GENERAL SUBSTANCE INFORMATION

Substance type : Inorganic
Physical status : Solid
Purity : > 97 %
Colour : White
Odour : Odorless
Remark : Typical for marketed substance
Granular material:
Barium carbonate > 97.7 %
strontium oxide < 1.4 %

High purity material:
Barium carbonate > 99.5 %
strontium oxide < 0.17 %

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (6), (5~~1~~2)

1.1.2 SPECTRA

1.2 SYNONYMS AND TRADENAMES

Synonym : Barium salt
Barium carbonate (1:1)
Barium carbonate ($BaCO_3$)
Barium monocarbonate
BW-C3
BW-P
C.I. 77099
C.I. Pigment White 10
Carbonic acid, barium salt
Pigment White 10
UN 1564 (DOT)
Carbonic acid, barium salt (1:1)
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (7), (51), (62)

1.3 IMPURITIES

CAS-No : 1633-05-2
EINECS No : 216-643-7
Name : Strontium carbonate ($SrCO_3$)
Value : 2.09 wt %
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 497-19-8
EINECS No : 207-838-8
Name : Sodium carbonate (Na_2CO_3)
Value : 0.16 wt %
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 471-34-1
EINECS No : 207-439-9
Name : Calcium carbonate ($CaCO_3$)
Value : 0.13 wt %
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 14265-45-3
EINECS No :
Name : Sulfite (SO_3)
Value : 0.11 wt %
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 1309-37-1

EINECS No : 215-168-2
Name : Ferric oxide (Fe_2O_3)
Value : 0.003 wt %
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 16887-00-6
EINECS No :
Name : Chloride (Cl^-)
Value : 0.005 wt %
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 7440-02-0
EINECS No : 231-111-4
Name : Nickel (Ni)
Value : < 5 ppm
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 7440-50-8
EINECS No : 231-159-6
Name : Copper (Cu)
Value : < 5 ppm
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 7440-47-3
EINECS No : 231-157-5
Name : Chromium (Cr)
Value : < 5 ppm
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 7440-48-4
EINECS No : 231-158-0
Name : Cobalt (Co)
Value : < 5 ppm
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 7440-62-2
EINECS No : 231-171-1
Name : Vanadium (V)
Value : < 5 ppm
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
21.01.2005 : (52)

CAS-No : 7439-89-6
EINECS No : 231-096-4
Name : Iron (Fe)
Value : 3.0 ppm
Source : Daehan Specialty Chemicals CO., LTD., Korea (joint venture of Solvay)
Reliability **:** (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (52)

1.4 ADDITIVES

1.5 TOTAL QUANTITY

Estimated production : Below is the Solvay estimation of the world market volume of barium carbonate.
2000: 540,000 tonnes/year, 2001: 540,000 tonnes/year, 2002: 550,000 tonnes/year, 2003: 580,000 tonnes/year, 2004: 601,452 tonnes/year
Solvay estimation of the split of the worldwide production by region in 2004 is as follows: China: 400,000 tonnes, Europe: 80,000 tonnes, Nafta: 35,000 tonnes, Korea: 16,452 tonnes, India: 30,000 tonnes, others: 40,000 tonnes
Remarks : Production figure received from B Schmit, 3 May 2004.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (58)

Estimated production : In Korea estimated production volume of barium carbonate was 26,626, 10,681, and 16,452 tonnes/year in 2002, 2003, and 2004, respectively.
In Nordic countries estimated production volume of barium carbonate was 2,017 tonnes/year in 2002.
Especially, estimated world production volume of barite ($BaSO_4$) among barium compounds was 5,890,000 tonnes/year in 1998.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (29), (52), (70)

1.6.1 LABELLING

Labelling : As in Directive 67/548/EEC
Symbols : Xn
E
Specific limits : No data
R-phrases : (22) Hamful if swallowed
S-phrases : (2) Keep out of the reach of children
(24/25) Avoid contact with skin and eyes
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (28)

1.6.2 CLASSIFICATION

Classification : As in Directive 67/548/EEC
Class of danger : Corrosive
R-phrases : (22) Hamful if swallowed
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (28)

1.6.3 PACKAGING

1.7 USE PATTERN

Type : Type
Category : Non dispersive use

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (28)

Type : Type
Category : Use resulting in inclusion into or onto matrix
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (28)

Type : Industrial
Category : In synthesis
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (28)

Type : Industrial
Category : In ceramics
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

TYPE : Industrial

Category : In paints
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial
Category : In enamels
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial
Category : In marble substitute
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial
Category : In rubber
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial
Category : In manufacture of paper
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial
Category : In barium salts
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial

Category : In electrodes
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial
Category : As an analytical reagent
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (12)

Type : Industrial
Category : As an additive for glaze
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (52)

Type : Use
Category : Fillers
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (28)

Type : Use
Category : Oxidizing agents
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (28)

Type : Use
Category : Laboratory chemicals
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (28)

Type : Industrial
Category : In magnets
Remarks : In Korea, barium carbonate is used for manufacturing magnets in a closed system.

Fe_2O_3 and $BaCO_3$ are mixed in water and ground in a mill and dehydrated. Then the material is heated at 1000 ~ 1200 ^{O}C.
Overall reaction is as follows;

$n Fe_2O_3 + BaCO_3$ (1000 ~ 1200 °C) → $BaO \cdot nFe_2O_3 + CO_2\uparrow$

After cooling and grinding, the Ferrite ($BaO \cdot nFe_2O_3$) powder is packed in 1ton bags.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (52)

Type : Industrial
Category In manufacture of television Braun tube

Remarks : In Korea barium carbonate is one of fifteen ingredients for manufacturing front glass of a television Braun tube.

Barium carbonate and other materials are mixed and homogenized in the mixer, then moved to a smelting furnace.

In this place barium carbonate turned into BaO and CO_2 gas.

$BaCO_3 \rightarrow BaO + CO_2\uparrow$

Then, the melted is molded into glass plates.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 : (52)

.

Type : Industrial
Category : Other
Remarks : Uses for Barium Carbonate A, B, C and D are listed below. The terms A, B, C and D categorize the material into different particle sizes. With A and B the residue on a > 45 micron filter is maximum 1 %. With C, sieve analysis shows max 5 % > 0.063 mm, and maximum 2 % > 0.200 mm. With D, sieve analysis shows 0 % > 1.000 mm, max 5% > 0.850 mm, and maximum 15 % < 0.150 mm.

Barium Carbonate A is used in the production of television glass, crystal glass and special glass, glazes, brick and tile industry, ceramic and ferrite industry.

Barium Carbonate B is used in brick and tile industry, ceramic and ferrite industry and for removing sulphates mainly in phosphoric acid production and chlorine alkali electrolysis.

Barium Carbonate C and Barium Carbonate D are used for the production of television glass, crystal glass and other special glass, glazes, frits and enamels. It is also used in the ferrite and chemical industries.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 (67)

Type : Use
Category : Other: Rat poison
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 (59)

1.7.1 DETAILED USE PATTERN

1.7.2 METHODS OF MANUFACTURE

Source : Other
Remarks : Barium carbonate is made using barium sulfide (black ash) dissolved in water and its clear solution is the usual raw material. There are two basic methods which differ mainly in the way the carbonate ion is introduced.

Soda ash method – barium sulfide is treated with sodium carbonate, either dissolved or in solid state, producing barium carbonate and sodium sulfide:

1) $BaS + Na_2CO_3$ yields $BaCO_3 + NaS$

2) $BaS + CO_2 + H_2O$ yields $BaCO_3 + H_2S$

The type of process depends on the market for sodium sulfide, the availability of cheap fuel, etc. The simplest method (equation 1) requires the largest investment as it requires the separation of sodium sulfide from the barium carbonate and turning the sodium sulfide in to a saleable product.

In the second equation, carbon dioxide is available at low cost and in high concentrations from the smoke stacks of the black ash rotary furnaces. The hydrogen sulfide can be converted to sulfur compounds or it can be converted to elemental sulfur.

The product from straight gassing process tends to be more impure than the soda-ash method. The precipitation, washing, drying and grinding of barium carbonate is performed in standard conventional equipment. Purity and size
specifications depend on the end use.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 (39)

Source : Other

Remarks : Solvay company produces Bbarium cCarbonate from barium sulfate using the following process:

$BaSO_4$ + Petrol coke (C_2) (1200°C) → BaS + CO_2
(CO_2 dedusted by wet scrubbing)

BaS + H_2O → Ba(OH)(SH)

Ba(OH)(SH) + CO_2 → $BaCO_3$ + H_2S

$BaCO_3$ powder drying → granulation by heat

H_2S → (heat) oxidation to S

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 (58)

Source : Production and process

Remarks : The raw material, barite and P-Coke is ground, dried and distributed first. These barite($BaSO_4$) and p-coke(C) are mixed and BaS is made after high burning(Rotary kin). By dissolving BaS in water, LEACH(BaSH(OH)) aqueous solution is generated. Barium carbonate suspension is produced by reaction of LEACH(BaSH(OH)) aqueous solution with carbon dioxide.

BaSH(OH) + CO_2 → $BaCO_3$ + H_2S(g) (Carbonation process)

The granular $BaCO_3$ is produced through drying, grinding, cooling, and crush of $BaCO_3$ suspension through granulation process.
The main product is packaged to 1ton bags.
The H_2S(g) generated in carbonation process is reacted with O_2 to produce liquid sulfer(Claus unit). In flue gas desulfurization unit, the unreacted gas from Clus unit and Rotary kin is removed by absorption in limestone slurry.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 (52)

Source : Natural origin

Remarks : Occurs in nature as the mineral witherite.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 : (12)

1.8 REGULATORY MEASURES

1.8.1 OCCUPATIONAL EXPOSURE LIMIT VALUES

Exposure limit value

Type :
value : 0.5 mg/m^3
Remarks : The Occupational Health and Safety Administration (OHSA) permissible exposure limit is 0.5 mg of soluble barium compounds per cubic meter of air, averaged over an eight-hour work shift. There is no STEL (Short Term Exposure Limit) value.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (56)

Exposure limit value

Type : ACGIH TLV
Value : TWA 0.5 $mg(Ba)/m^3$
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (1)

Exposure limit value

Type : OEL – HUNGARY
Value : Short term exposure limit 0.5 $mg(Ba)/m^3$, JAN 1993
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (31)

Exposure limit value

Type : OEL – KOREA
Value : TWA 0.5 $mg(Ba)/m^3$
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (32)

1.8.2 ACCEPTABLE RESIDUES LEVELS

Remarks : A criterion of 1.0 mg/L was set by the EPA (Environmental Protection Agency) for domestic water supplies on a health basis. A drinking water guideline was derived from the 8-hour weighted maximum allowable concentration in industrial air of 0.5 mg/m^3. It was assumed that, with an 8-hour inhalation of 10 m^3 of air, the daily intake would be 5 mg of barium. 75 % of 5mg is absorbed in the blood stream and 90 % of absorbed barium is transferred across the gastrointestinal tract. Based on the above assumption, it was reasoned that a concentration of 2 mg/L of water would be safe for adults. To provide added safety for more susceptible members of the population, such as children, a level of 1 mg/L was recommended.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (21)

1.8.3 WATER POLLUTION

1.8.4 MAJOR ACCIDENT HAZARDS

1.8.5 AIR POLLUTION

1.8.6 LISTINGS E.G. CHEMICAL INVENTORIES

1.9.1 DEGRADATION/TRANSFORMATION PRODUCTS

1.9.2 COMPONENTS

1.10 SOURCE OF EXPOSURE

Source : Production and processing
Remarks : During processing the main risk is likely to be dust during the drying and/or packaging process. Adequate controlled exhaust systems are in place to limit dust formation and emission.

Solvay has 2 own plants: Honningen (Ge) and Massa (It) and joint ventures with 3 other plants: Onsan (Korea), Monterrey (Mex) and Kalahasti (India)

The legal emission limits for the sites are listed below:

Honningen:
Dust to air: 20 to 50 mg/m^3
Waste water: Ba: 5 mg/l

Massa:
Dust to air: 20 to 150 mg/m^3
No waste water emission limit for Ba

Onsan:
Dust to air: 120 mg/m^3
No waste water emission limit for Ba

Monterrey:
Dust to air: 220 to 660 mg/m^3
No waste water emission limit for Ba

Kalahasti:
Dust to air: 115 mg/m^3
No waste water goes outside the plant

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.

21.01.2005 (58)

Source : Environment
Remarks : Barium is the 16th most abundant non-gaseous element of the Earth's crust, constituting approximately 0.04 % of it. The two most prevalent naturally occurring barium ores are barite (barium sulfate) and witherite (barium carbonate). The element is released to environmental media by both natural processes and anthropogenic sources.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (30), (82)

Source : Environment
Remarks : Anthropogenic sources of barium are primarily industrial. Emissions may result from mining, refining, or processing of barium minerals and manufacture of barium products. Barium is released to the atmosphere during the burning of coal, fossil fuels and waste. Barium is also discharged in wastewater from metallurgical and industrial processes. Deposition on soil may result from human activities, including the disposal of fly ash and primary and secondary sludge in landfills. Estimated releases of barium and barium compounds to the air, water and soil from manufacturing and processing facilities in the USA during 1998 were 900, 45, and 9,300 tonnes, respectively.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (82)

Source : Environment
Remarks : According to Toxics Release Inventory (TRI), an estimated total of 0.6 million, 0.3 million, and 14.9 million pounds of barium and barium compounds were released to the atmosphere, water and soil respectively from manufacturing and processing facilities in the Unites States in 1987.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (30)

Source : Environment
Remarks : In the 2002 US-EPA TRI reports, releases of barium compounds into the environment as follows(tons):

Air	Water	Land	Underground Injection	Total On Site Releases	Total Off- Site Releases	Total On and Off-Site Releases
1042.2	573.6	73633.3	16.4	75265.6	21505.6	96771.3

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (78)

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005

Source : Human: exposure by production and processing
Remarks : In the production facilities, dust might be released in the air from loading silos, granulation, packaging and shipping processes. Since packaging process is in the open and manual system, workers have higher potential risk. They were provided with the appropriate PPE(Personal Protective Equipment) such as dust masks, and workplaces were managed by safe work practices.
In the processing facilities, workers were exposed to barium carbonate dust during putting raw materials (barium carbonate) or mixing processes. The following controls are being applied to reduce employees exposure: engineering controls such as local ventilation systems; administration controls such as regulation of industrial safety and health and safe work practices within a company; and the use of PPE such as dust masks, gloves, and aprons. The monitoring data in glass manufacturing factories,

air concentration levels of dust for workplace were less than 0.4 mg/m^3, which was below Korea permissible exposure limit of 10 mg/m^3. In addition, airborne barium ranged from 0.0002 to 0.0004 mg/m^3 was recorded to be below the American Conference of Governmental Industrial Hygienists threshold limit value (0.5 mg Ba/m^3). The periodical medical examinations showed no adverse health effect that could be attributed to barium carbonate.

21.01.2005 (52)

1.11 ADDITIONAL REMARKS

1.12 LAST LITERATURE SEARCH

1.13 REVIEWS

2.1 MELTING POINT

Value : 1,740 °C
Remarks : At 90 atmosphere
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
Flag : Critical study for SIDS endpoint
21.01.2005 : (3), (62)

Value : 1,790 °C
Remarks : At 90 atmosphere
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 : (82)

Value : ca. 1,400 - 1,740 °C
Decomposition : Yes
Remarks : Melting point at pressure of 90 bar. Decomposition beginning at 1400 °C
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (28)

Value : = 811 °C
Remarks : Melting point at 1 atmosphere.
Reliability : (4) Not assignable
4b – Secondary literature
21.01.2005 (25)

2.2 BOILING POINT

2.3 DENSITY

Type : Density
Value : 4.3 g/cm^3
Temperature : 20 °C
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
Flag : Critical study for SIDS endpoint
21.01.2005 (28)

Type : Density
Value : = 4.2865 g/cm^3 at °C
Method :
Year :
GLP : no data
Test substance :
Remarks : Temperature for density value not given.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (47)

Type : Density
Value : = 4.275 g/cm^3 at °C
Method :
Year :
GLP : no data
Test substance :

Remarks	:	Temperature for density value not given.
Reliability	:	(4) Not assignable 4b – Secondary literature
21.01.2005		(25)

Type	:	Relative density
Value	:	= 4.43
Method	:	
Year	:	
GLP	:	no data
Test substance	:	
Remarks	:	
Reliability	:	(2) Reliable with restrictions 2g - Data from handbook or collection of data.
21.01.2005		(82)

2.3.1 GRANULOMETRY

2.4 VAPOUR PRESSURE

Remarks	:	Essentially zero
Reliability	:	(4) Not assignable 4b – Secondary literature
21.01.2005		(56)

2.5 PARTITION COEFFICIENT

Remarks	:	Not applicable; inorganic salt.
21.01.2005		

2.6.1 WATER SOLUBILITY

Value	:	24 mg/L
Temperature	:	25 °C
Remarks	:	Slightly soluble (1:1000) in carbonated water. Soluble in dilute hydrochloric, nitric acid, or acetic acid. Also soluble in solutions of ammonium chloride or ammonium nitrate.
Reliability	:	(2) Reliable with restrictions 2g - Data from handbook or collection of data.
Flag	:	Critical study for SIDS endpoint
21.01.2005		(47)

Value	:	20 mg/L
Temperature	:	26 °C
Remarks		Soluble in acid and ammonium chloride. Insoluble in alcohol.
Reliability	:	(2) Reliable with restrictions 2g - Data from handbook or collection of data.
21.01.2005		(73)

Value	:	20 mg/L
Temperature	:	20 °C
Reliability	:	(2) Reliable with restrictions 2g - Data from handbook or collection of data.

21.01.2005 (82)

Value : c.a. 16 mg/L
Temperature : 16 °C
~~Ph~~ pH : 7 – 8
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (28)

Value : c.a.60 mg/L
Temperature : 100 °C
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (28)

Value : 22 mg/L
Temperature : 18 °C
Remarks : Soluble in ethanol.
Reliability : (4) Not assignable
4b – Secondary literature
21.01.2005 (59)

Remarks : Insoluble in water.
Soluble in acids, except sulfuric.
Reliability : (4) Not assignable
4b – Secondary literature
21.01.2005 (25)

Value : 22 mg/L
Temperature : 20 °C
Reliability (4) Not assignable
4b – Secondary literature
21.01.2005 (56)

2.6.2 SURFACE TENSION

2.7 FLASH POINT

2.8 AUTO FLAMMABILITY

Value :
Remarks : No data; of limited relevance, solid at > 400 °C
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (28)

2.9 FLAMMABILITY

Result : Other
Remarks : data of limited relevance: solid at ambient temperature
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (28)

2.10 EXPLOSIVE PROPERTIES

Remarks : Not applicable
Reliability : (4) Not assignable
4b – Secondary literature
21.01.2005 (44)

2.11 OXIDIZING PROPERTIES

Result : no oxidizing properties
21.01.2005

2.12 DISSOCIATION CONSTANT

2.13 VISCOSITY

2.14 ADDITIONAL REMARKS

3.1.1 PHOTODEGRADATION

3.1.2 STABILITY IN WATER

Remarks : Under natural conditions barium will form compounds in the +2 oxidation state. Barium does not hydrolyze appreciably except in highly alkaline environments.
As pH levels increase above 9.3 and in the presence of carbonate, barium carbonate becomes the dominant species. Barium carbonate also exhibits fast precipitation kinetics and very low solubility.
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
21.01.2005 (30)

3.1.3 STABILITY IN SOIL

3.2.1. MONITORING DATA

Type of measurement : background concentration
Media : Air
Remarks : Ambient barium concentrations ranged from 0.0015 to 0.95 µg /m^3 of air in a USA survey.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (77)

Type of measurement : background concentration
Media : Air
Remarks : Barium concentrations ranging from < 0.005 to 1.5 µg/m^3 air have been detected in 18 cities and 4 suburban areas in the USA.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (71)

Type of measurement : background concentration
Media :
Remarks : In the USA most surface waters and groundwaters have barium present at levels ranging from 2 - 340 µg/L.
Most of the drinking water contains barium levels of < 0.2 mg/L.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (42)

Type of measurement : background concentration
Media : drinking water
Remarks : The Illinois Environmental Protection Agency identified 16 cities and three sub-divisions as having drinking water with barium concentrations

exceeding 1 mg/L (the then current state and federal drinking water standard), Barium concentration ranged from 1.0 to 10 mg/L.

The barium was thought to be naturally occurring.
Community water supplies from deep rock and drift wells in northeastern Illinois so exceeding level of barium concentration in groundwater supplies may be due to leaching and erosion of barium from sedimentary rocks.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (13)

Type of measurement : background concentration
Media : other: sewage sludge
Remarks : 30 sewage samples from 23 American cities were analyzed. Barium concentration range was 15.6 to 5,665 mg/kg (dried weight).
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (49)

Type of measurement : concentration at contaminated site
Media : Water
Method : Rodney J. Nakamoto *et al* 1992
Remarks : Single water quality monitoring stations were established on the Merced River (does not receives tile drainage) and the Salt Slough (receives tile drainage), tributaries to the San Joaquin River, California, during 1988. Duplicate water quality measurements were taken at three equal intervals across the channel. Composite samples of filtered and unfiltered water from the channel were collected for laboratory analysis of trace elements. Barium concentration in water was measured with inductively coupled argon plasma emission spectrometry (ICP).
Results : Barium levels in composite water samples (mean of 5):

Merced River	0.034 µg/mL (filtered sample)
	0.043 µg/mL (unfiltered sample)
Salt Slough	0.065 µg/mL (filtered sample)
	0.101 µg/mL (unfiltered sample)

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (50)

Type of measurement : background concentration
Media : Food
Remarks : Barium content in milk was found to range between 45 and 136 µg/g.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 : (28)

Type of measurement : background concentration
Media : Food
Remarks : Barium content of edible crops ranges from 10 ~~u~~µg/g in wheat to 3 – 4 mg/g in brazil nuts.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 : (28)

Type of measurement : background concentration
Media : Seawater
Remarks : The concentration of barium in seawater varies greatly among different oceans and varies with factors such as latitude and depth within a given ocean. The concentration increases with the depth of water. Measured concentration of barium in seawater was ranged from 0.04 – 37 mg/L.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (82)

Type of measurement : background concentration
Media : Soil
Remarks : The background level of barium in soils is considered to range from 100 to 3,000 mg/kg with an average of 500 mg/kg.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (82)

Type of measurement : background concentration
Media : Sea water and fresh water
Remarks : Concentration of barium element in seawater is 6 µg/L; and in fresh water 7 – 15000 (average 50) µg/L.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (63)

3.2.2 FIELD STUDIES

Type of measurement : other: Not available
Media :
21.01.2005

3.3.1 TRANSPORT BETWEEN ENVIRONMENTAL COMPARTMENTS

Type : other: no tests
Media :
Air : % (Fugacity Model Level I)
Water : % (Fugacity Model Level I)
Soil : % (Fugacity Model Level I)
Biota : % (Fugacity Model Level II/III)
Soil : % (Fugacity Model Level II/III)
Method :
Year :
Remarks : Since the compound is in a solid state and poorly soluble in water, any dust released is likely to deposit mainly upon soil or sediment.

21.01.2005

3.3.2 DISTRIBUTION

Media : other: soil water air
Method :
Year :
Remarks : Most barium released to the environment from industrial sources is in forms that do not become widely dispersed. In the atmosphere, barium is likely to be present in particulate form. Although chemical reactions may cause changes in speciation of barium in air, the main mechanisms for the removal of barium compounds from the atmosphere are likely to be wet and dry deposition.
In the aquatic media, barium is likely to precipitate out of solution as an insoluble salt (i.e., as $BaSO_4$ or $BaCO_3$). Waterborne barium may also adsorb to suspended particulate matter.
Barium mobility in soil is reduced by the precipitation of barium carbonate and sulfate.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
21.01.2005 : (30)

Type : Other: laboratory, aerobic test system
Test substance : Radioactive isotopes: $^{133}Ba^{2+}$
Remarks : Eighteen soil/soil-solution phase systems resulting from the combination of two soils with nine liquid phases were used to determine the distribution between soil and soil solution of Ba.
Industrial and domestic anaerobically digested sludges were used. After an equilibration period of between 2 and 4 weeks, with constant stirring and aeration, sludge supernatants were again collected after centrifugation. Dry matter contents of the sludges, determined after drying at 105 °C for 20 hours, ranged from 1 to 3 %. Organic matter, determined as weight loss after ashing at 600 °C for 4 hours, corrected for carbonate, was 50 – 60 % of total dry matter. Soil adsorption was determined with a series of solutions where the elemental concentration ranged from 0 to 5 mg/kg above the concentration of the initial solution. The soil/solution mixtures were equilibrated for 3 days at 20 °C. The radioactive isotopes were obtained as chlorides or nitrates in the valence states most likely to occur in aqueous colutions (pH 4 – 8) under atmospheric pressure and O_2 level.

Table. Characteristics of soils used in the adsorption experiments

Soil type	pH (H_2O)	Moisture (of oven dry wt, g/g)	Organic matter (g/g)	Clay (g/g)	Cation exchange capacities (meq/g)
Sandy	5	0.11	0.035	0	0.22
Sandy loam	8	0.25	0.025	0.2	0.16

Results : The solution concentration range of barium was 10 - 10^2 µg/L in anaerobically digested sludge and 10^2 – 10^3 µg/L in idem after extensive aeration and the distribution constant range was 10^4 - 10^5 mL/g in anaerobically digested sludge and 10^3 - 10^4 mL/g in idem after extensive aeration of sewage sludge.
The general conclusion is that the sludge solutions appeared to increase the mobility of elements in soil.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint

21.01.2005 (18)

Species : *Scenedesmus obliquus* Kütz and *Chlorella kessleri* Fott et Nov. (green algae)
Exposure period : 15 days
Concentration :
BCF : No data
Elimination :
Method : B. Havlik *et al*, 1980
Year :
GLP : No data
Test substance : Barium chloride (radioactive isotope $^{133}Ba^{2+}$ in the form of chloride)
Test conditions : The composition of cultivation medium: 2.02 g KNO_3; 0.34 g KH_2PO_4; 0.99 g $MgSO_4.7H_2O$; 0.017 g $FeCl_3$ and 0.00156 g $CaCl_2$ in 1 L redistilled water. The bottles were cultivated at 27 ^OC with continual illumination of 4,000 lux and bubbled with air containing 5 % carbon dioxide.
Remarks : When the algae growth was in the logarithmic phase, $^{133}Ba^{2+}$(as chloride) was added to the cultures in an amount to give a final activity of 95, 11, and 1 kBq/L of medium and the final concentration of barium ion was 4.0, 0.46, and 0.04 µg/L of medium. Samples were taken on exposure days 1, 4, 7, and 15. At each sampling time, 3 mL of algae suspension was measured for total activity and 5 mL was filtered (Synpor No 1, 4 µm pore size) and 3 mL of the filtrate was taken to determine ^{133}Ba content in the medium. The filter with the algae was washed in 5 mL of 0.2 M chelaton III solution and the activity of the washing-out of algae was measured. Each determination was made in duplicates.
Gamma radiation of $^{133}Ba^{2+}$ was measured integrally by well crystal scintillator of the measuring system NZQ 717-T, of Tesla Premysleni, CSSR.
Results : Barium absorption in both species of algae increased proportionally with decreasing barium concentration in the medium.

Table. Cumulation of ^{133}Ba in algae

Algal species	Days of exposure	Concentration of $^{133}Ba^{2+}$ in algae (%)		
		0.04 µg/L	0.46 µg/L	4.0 µg/L
Scenedesmus obliquus	1	8	8	12
	4	18	22	14
	7	37	23	16
	15	58	54	30
Chlorella kessleri	1	8	8	7
	4	14	14	16
	7	35	27	29
	15	42	35	31

100 % = the amount of barium added to the medium at the beginning of the experiment

Table. Growth of algae during the experiment

Algal species	Concentration of $^{133}Ba^{2+}$ in algae (µg/L)	Cell density: 10^4 in mL	
		beginning	end
Scenedesmus obliquus	0.04	18	230
	0.46	51	465
	4	13	104
Chlorella kessleri	0.04	15	368
	0.46	16	282
	4	27	352

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint

21.01.2005 (24)

3.4 MODE OF DEGRADATION IN ACTUAL USE

Memo : During use in glass production, barium carbonate breaks down at a high temperature to barium oxide, releasing carbon dioxide.

21.01.2005

3.5 BIODEGRADATION

3.6 BOD5, COD OR BOD5/COD RATIO

3.7 BIOACCUMULATION

Species : *Lepomis macrochirus* (Bluegill)
Method : Rodney J. Nakamoto *et al* 1992
Year : 1988
GLP :
Test substance : Barium (The paper did not report which salt was used.)
Remarks : The effects of water quality and exposure to trace elements in irrigation return flows on bluegills (Lepomis macrochrius) were studied in the Merced River (does not receives tile drainage) and Salt Slough (receives tile drainage), tributaries to the San Joaquin River, California, during 1988.

Scale samples were collected from the left side of the body under the posterior half of the pectoral fin. Ten composite carcass and 10 composite gonad samples either from 2 females bluegills or 3 male bluegills were analyzed. Barium concentration in tissue samples was measured with inductively coupled argon plasma emission spectrometry (ICP). Barium concentrations were log transformed.

Table. Water quality in the Merced River and the Salt Slough, Califonia.

Sample	Temp. (°C)	DO (mg/L)	pH	Turbidity (NTU)	Hardness (mg/L $CaCO_3$)	Alkalinity (mg/L $CaCO_3$)
The Merced River	22.0	8.1	7.40	10.1	60.1	60.3
Salt Slough	20.6	7.3	7.72	72.7	422.7	147.1

Results : Bioconcentration factor (~~u~~µg/g wet weight of bluegill tissue)/(~~u~~µg/~~Ml~~mL unfiltered water) for barium in bluegills:

Merced River Male carcass 74.4
gonad insufficient data for calculation
Female carcass 68.4
gonad 6.4

Salt Slough Male carcass 20.2
gonad insufficient data for calculation
Female carcass 22.8
gonad 1.2

Mean barium concentration (~~u~~µg/g dry weight of tissue) in composite bluegill tissue sample:

Merced River	Male	carcass 12.9
		gonad below detection level (< 0.1)
	Female	carcass 11.9
		gonad 0.8
Salt Slough	Male	carcass 8.2
		gonad below detection level (< 0.1)
	Female	carcass 7.0
		gonad 0.4

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

21.01.2005 (50)

3.8 ADDITIONAL REMARKS

4.1 ACUTE/PROLONGED TOXICITY TO FISH

Type : Static
Species : *Gambusia affinis* (Fish, fresh water)
Exposure period : 96 hr
Unit : mg/L
TLm : > 10,000
Method : I. E. Wallen *et al*, 1957
Year :
GLP : no data
Test substance : Barium carbonate
Remarks : The toxicity of certain pure chemicals in turbid waters was tested. The water used for experimental dilutions and control aquaria was brought in from two farm ponds which had a long history of high turbidity. The pH of the water was usually between 7.8 and 8.3, which was approximately average for the area. The experimental aquaria were cylindrical pyrex jars 12 inches high and 12 inches in diameter containing 15 L of the turbid water at start of test. Water was not replaced. Artificial aeration helped to maintain oxygen levels, to mix chemicals into the water (added as "chemically pure" compounds) and to disperse the turbidity producing soil as long as possible.

The fishes were all collected from Stillwater Creek in Payne Country, Okla. and all the fishes used were adult females.
Ten fish were used in each aquarium during all experiments and a control aquarium was always maintained with 10 fish. All fishes were transferred to the test aquaria as soon as the chemical had been mixed into them. The experiments were continued for at least 96 hours with checks made of 24-, 48-, 72-, and 96-hour survivors. The fishes were not fed during testing. Dilutions selected for all first experiments with a chemical were based on the progressive bisection of intervals on a log scale: 10, 18, 32, 56, and 100 mg/L. If deaths did not occur the same series was run between 100 and 1,000 mg/L. Again if no deaths occurred, between 1,000 and 10,000 mg/L.

Results : A median tolerance limit (TLm) was determined. Barium carbonate test conditions and results are given below: -

Temperature range 17 – 20 degrees C
Turbidity initial 380 mg/L; final 140 mg/L
pH (testing water) 7.6 – 8.5
TLm 24 h > 10,000 mg/L
48 h > 10,000 mg/L
96 h > 10,000 mg/L

Although 2 fishes were dead at 10,000 mg/L they showed no symptoms of poisoning and it seemed likely that the TLm was considerably greater than 10,000 mg/L. No significant change occurred in either ~~Ph~~pH or turbidity during the test.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (80)

Type : Static
Species : *Cyprinodon ariegates* (Sheepshead minnows, seawater)
Exposure period : 96 hr
Unit : mg/L
LC_{50} : > 500

Method : other: “Methods for acute toxicity tests with fish, macroinvertebrates and amphibians” U.S. EPA 1975.
Year : 1981
GLP : no data
Test substance : Barium (Paper does not state which salt of barium was used.)
Remarks : - *Test Organisms*
Age: Juvenile (14 – 28 days old posthatch)
Length: 8 – 15 mm
Loading: Tests were conducted in either 4-L glass jars that contained 3 L of test solution or 19-L glass jars that contained 15 L.
Supplier: EG & G Bionomics Marine Research Laboratory or the EPA’s Environmental Research Laboratory, Gulf Breeze, FL. Fish were maintained in the laboratory in flowing, filtered (10 – um) seawater of ambient salinity from 10 – 31 ‰ and temperature from 25 – 31 °C.

All dilutions were made using filtered (5 um), natural seawater of ambient salinity. Test concentrations were prepared by direct addition of weighed amounts of test material to seawater or by pipetting appropriate volumes of weighed amounts of test material mixed with solvent/carrier.

The paper does not state which method was used for barium, nor does it state which salt of barium was used. Ten fish were tested per container. There was no aeration. Mortality was recorded at 24, 48, 72, and 96 hours; dissolved oxygen concentration was measured at test initiation and daily thereafter; pH was measured in control and the low and high test concentrations at test initiation and 96 h of testing. No correction was made for control mortality.

LC_{50} value and 95 % confidence limits were calculated by selection of three statistical methods in the following order: moving average angle, probit, or biniminal probability.
Results : Nominal concentration was used. Barium LC_{50} at 24-, 48-, 72-, and 96-hour was > 500 mg/L. The no observed effect concentration was 500 mg/L. Although not stated, it could be assumed that the maximum concentration was 500 mg/L.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (26)

4.2 ACUTE TOXICITY TO AQUATIC INVERTEBRATES

Type : Static
Species : *Daphnia magna* (Crustacea)
Exposure period : 48 hour(s)
Unit : mg/L
NOEC : 68 nominal
LC_{50} : 410
Method : Methods for Acute Toxicity Tests with Fish, Macroinvertebrates, and Amphibians (US EPA, 1975)
Year :
GLP : no data
Test substance : Barium, purity = > 80 %
Remarks : The purpose of this study was to determine the acute toxicity of selected chemicals, which included barium (salt not stated), to the water flea (*Daphnia magna*).

- *Test Organisms*

Age: juveniles within 24 hours old.
Supplier: laboratory stocks cultured at EG&G, Bionomics

- *Test Conditions*
Dilution water source: reconstituted water
Water chemistry:, DO; 3.5 – 9.1 mg/L
pH; 6.7 – 8.1 in hardness of 72 mg/L as $CaCO_3$
pH; 7.4 – 9.4 in hardness of 173 mg/L as $CaCO_3$
Temperature: 22 ± 1 °C

It is not clearly stated in the paper how the barium was added to the test jars or which concentrations were tested (5 – 8 nominal concentrations tested). The test chemical was added to 500 mL of diluent water in a 2-L jar to prepare the test solution. If soluble, the solution was divided into three 150 mL aliquots in 250 mL beakers. Remaining 50 mL of control, low, mid and high concentration used to measure 0-h oxygen and pH. Five daphnids were randomly placed in each 150 mL of solution within 30 minutes of preparation. If test material was not soluble, the 500 mL was not divided
and 15 daphnids were placed directly in the 2-L jar prior to addition of test material. Observation of test populations were made at 24 and 48 h of exposure and mortalities recorded.

LC_{50} and 95 % confidence limits were estimated using one of three possible methods – i) moving average angle method; ii) probit analysis; or iii) binomial probability analysis. The calculation was performed on a calculator programmed to scan the data and select the most appropriate method. If no mortality was observed at highest concentration tested, it was reported as greater than the highest tested concentration.

Results

Barium (salt not stated in publication)
24 h LC_5 0 > 530 mg/L
48 h LC_{50} 410 mg/L (320 – 530; 95 % confidence interval)
No discernible effect concentration 68 mg/L

Paper does not state which salt of barium was used.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (40)

Type : Static
Species : *Daphnia magna*
Exposure period : 48 hours
Unit : mg/L
EC_{50} : 32
Analytical monitoring : No
Method :
Year : 1989
GLP : No data
Test substance : Other TS: Barium sulfate ($BaSO_4$, CAS No. 7727-43-7), reagent grade
Test conditions : - *Test Organisms*
Supplier: a natural pond situated at Gheru Campus of the Industrial Toxicology Research Centre, Lucknow
- *Test Conditions*
Dilution water source: filtered aerated tubewell hard water
Water chemistry: hardness – 240 mg/L as $CaCO_3$, alkalinity – 400 mg/L

as $CaCO_3$, Ca – 145 – 165 mg/L, Mg – 85 – 96 mg/L, Cl – 5 – 10 mg/L
pH: 7.2 – 7.8
Temperature: 11.5 – 14.5 °C

Stock solutions were made in distilled water and a few drops of dilute HCl were added to the stock solution in order to dissolve the salts. Test concentrations were selected on a logarithmic scale as outlined. Ten daphnids were exposed to each concentration and each concentration was prepared in replicates of three. Tests were conducted in 200 mL beakers containing 100 mL of test water.
EC_{50} values and 95 % confidence limits were calculated by moving average-angle method.

Results : The solutions of Ba showed precipitation 3 – 5 hour after addition of the metal substance. EC_{50} value at 24 hour was 52.8 mg/L and 95 % confidence limits was 43.2 – 68.1 mg/L.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 : (11)

Type : Static
Species : *Daphnia magna*
Exposure period : 48 hours
Unit : mg/L
LC_{50} : 14.5
Analytical monitoring : Yes
Method : K.E.Biesinger and G.M.Christensen, 1972
Year : 1972
GLP : No data
Test substance : Other TS: Barium chloride dihydrate ($BaSO_4 \cdot 2 H_2O$, CAS No. 10326-27-9), purity = American Chemical Society reagent-grade chemicals
Test conditions : - *Test Organisms*
Supplier: a laboratory clone originally obtained from the University of Michigan.
Age: 12 ± 12 hr old
10 daphnids were placed in duplicate test chambers.
- *Test Conditions*
Dilution water source: Lake Superior water
Water chemistry: Total hardness – 45.3 mg/L, Alkalinity – 42.3 mg/L Chloride – 1.2 mg/L, Sodium – 1.1 mg/L, Calcium – 13.7, Magnesium – 3.1 mg/L, Potassium – 0.5 mg/L, Strontium-0.02 mg/L, Barium – 0.01 mg/L, Iron – 0.02 mg/L
pH: 7.4 – 8.2
Temperature: 18 ± 1 °C
Light: 16-hr photoperiod, Light intensity: 115 ft-c

Dissolved oxygen concentrations in test containers were near saturation at all times.There was no feeding during the test.
Results were statiscally evaluated with the method of Litchfiedl and Wilcoxon (1949).

Results : 64 hr EC_{50} value was 19.1 mg/L.
Reliabilities : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (9)

Type : Static
Species : *Daphnia magna*

Exposure period : 64 hours
Unit : mg/L
EC_{50} : 29
Analytical monitoring : No data
Method : Anderson, 1944 and 1946
Year : 1948
GLP : No data
Test substance : Other TS: Barium chloride ($BaCl_2$, CAS No.)
Test conditions : - _Test Organisms_
Age: 4 ± 4 hr old
- _Test Conditions_
Dilution water source: Lake Erie water

Barium chloride concentrations above 333 mg/L in Lake Erie water had a precipitates but below 666 mg/L no precipitate was discernable so that a precipitate was not a limiting factor at the toxicity threshold.
Reliability : (3) Not reliable
3a – Documentation insufficient for assessment
21.01.2005 : (4)

Type : Static
Species : *Daphnia magna*
Exposure period : 24 hours
Unit : mg/L
EC_{50} : 209.3
Analytical monitoring : No
Method : OECD TG 202, "*Daphnia sp*., Acute Immobilisation Test and Reproduction Test"
Year : 1984
GLP : No data
Test substance : Other TS: Barium nitrate, purity = > 97 %
Remarks : 3 replicates were used.
The pH of the test solutions was not adjusted to the recommended pH range since it affects the toxicity.
The 24-h EC_{50} were calculated by the Trimmed Spearman-Karber method (Hamilton *et al.* 1977).
Reliabilities : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
21.01.2005 (45)

Type : Static
Species : *Daphnia magna*
Exposure period : 24 hours
Unit : mg/L
EC_{50} : 133.8
Analytical monitoring : No
Method : The OECD standard protocol (1980) with a few modification
Year : 1994
GLP : No data
Test substance : Other TS: Barium nitrate, reagent grade
Test conditions : - _Test Organisms_
Age: juveniles within 24 hours old.
Supplier: the Department of Biology, University of Turku
The daphnia were cultured in M4 media.
- _Test Conditions_
Dilution water source: Standard Reference Water
Water chemistry: $NaHCO_3$ 2.4 mM, K_2SO_4 0.15 mM, $CaCl_2$ 2.0 mM, KH_2PO_4 0.01 mM, pH 7.6

Temperature: 21 ± 1 °C
Light precocity: 16/8 (light/dark)

Twenty daphnia were introduced into 100 mL polystyrene vessels with 50 mL liquid in each and the vessels were closed with a polyethene cap.
There was no feeding and no aeration during the tests.The test was repeated at least three times.
Solvents (methanol or ethanol) were dissolved up to chemical's solubility limits and at the highest concentration of solvents used, no increase in lethality.
EC_{50} values were calculated using regression analysis after linearisation of dose/response curves by logarithmic transformation of the concentrations (statistical program; GraphPad 4).

Reliabilities : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

21.01.2005 (27)

Type : Static
Species : other aquatic mollusc: *Mytilus Californianus*
Exposure period : 48 hour(s)
Unit : µg/L
NOEC : = 100 measured/nominal
EC_{50} : = 189
Analytical monitoring : Yes
Method : Spangenberg, J.V. and Cherr, G.N, 1995
Year : 1995
GLP : no data
Test substance : Barium acetate
Test conditions : - *Test Organisms*
Age: Adult Califonia mussls (*M. Californianus*)
Supplier: intertidal regions of Bodega Marine Reserve, Bodega Bay, California, USA
The mussls were cultured in seawater containing the cultured marine algae. The algal solution was replaced with 0.45-µm filtered Bodega Bay seawater (FSW; 13 °C) in the containers of the animals that did begin to spawn. Three separate male and female pairs of California mussels were used for the barium exposure experiments; triplicate (sometimes quadruplicate) gametes of each pair were exposed to a concentration range of 0 to 20 mg/L.
- *Test Conditons*
All stock solutions were made in twice-distilled water (DDH_2O) and were diluted into FSW, with the DDH_2O never exceeding 1 % of the seawater solution volume. Negative controls received the equivalent colume of DDH_2O only.

Remarks : Embryo Exposure
Embryos were cultured in filtered Bodega Bay seawater (FSW), pH 7.8, at 12 degrees C until hatching. After hatching, embryos were exposed to barium (as barium acetate) at concentrations of 0 to 20 mg/L. All embryos were fixed at 48 hours and subsequently scored for shell morphology. Water samples were collected from two of the three pairs of animals and analyzed for dissolved barium (particulate barium was filtered out).

Stage-Specific Developmental Exposures
Embryos (from four pairs) were exposed to 500 ~~u~~µg/L barium for varying lengths of time at different points during the 64-hour post-fertilization stage:

1) 0 – 16 h early cleavage (after fertilization)
2) 0 – 32 h early cleavage-trocophore
3) 0 – 64 h early cleavage-veliger

4) 16 – 32 h gastrula-trocophore
5) 16 – 64 h gastrula-veliger
6) 32 – 64 h trocophore-veliger

At each stage controls were run in parallel, and all exposure and control experiments were conducted in triplicate. For exposure that ended prior to 64 h, the solution was removed at the appropriate time, embryos washed three times in FSW and resuspended in FSW. All embryos were fixed at 64 h. Additionally two extra replicates (one exposed and one control) were included and preserved at the end of each window. This allowed assessment of the progression of effects initiated prior to 64 h. After fixing, embryos were assessed for normal shell development and calcification.

Samples were analyzed for Ba only on an inductively coupled argon plasma (ICP) emission spectrometer.

Statistical Methods
Data from the three pairs used in the embryo exposure studies were pooled. Mean values (+/-SD) were calculated for each exposure concentration. Values normalized for control and significance levels for differences between groups were calculated. ToxCalc 3.4 software (Tidepool Scientific Software, McKinleyville, CA, USA) was used for computation of statistical parameters. The no-observed-effect concentration (NOEC), the lowest-observed-effect concentration (LOEC) and the 50 % effective concentration (EC_{50}) were calculated.

For stage-specific experiments, the mean (+/- SD) for the 12 values of percent normal development were calculated for each exposure window. Mean values were normalized for control.

Result : Embryo Exposure
Barium induced abnormal development in *M. Californianius* embryos. Free-swimming veliger larvae exhibited abnormal morphology and apparent developmental delay following 48-h exposure to barium at nominal concentrations between 200 and 800 ~~u~~µg/L (1.4 to 5.6 Um). Barium concentrations greater than 1 mg/L were associated with a white precipitate.

Measured (4 replicates) barium (mg/L) concentrations vs.nominal

Nominal	Measured
Control	0.03; < 0.03; < 0.03; < 0.03
0.2 mg/L	0.23; 0.21; 0.20; < 0.03
0.4 mg/L	0.47; 0.47; 0.43; 0.40
0.6 mg/L	0.51; 0.46; 0.56; 0.57
0.8 mg/L	0.46; 0.51; 0.55; 0.54
1 mg/L	0.05; 0.04; 0.04; 0.05
5 mg/L	0.03; < 0.03; < 0.03; < 0.03

The measured concentrations are affected by the precipitation of a Ba-salt. It seems that the solution is saturated between 0.4 and 0.6 mg/l barium acetate. However, a further increase in the nominal concentration led to a measured concentration lower than the concentration at saturation. The NOEC determined from dose-response data was 100 µg/L. The EC_{50} was found to be 189 µg/L.

A toxic effect associated with exposure of a sensitive marine invertebrate to low levels of soluble barium in seawater (200 µg/L). Concentrations greater than 900 µg/L showed no increase in toxicity relative to control. Since the majority of adverse effects of barium on mussel development were observed near the time of gastrulation, it would appear that barium affects cell differentiation.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

21.01.2005 (69)

4.3 TOXICITY TO AQUATIC PLANTS E.G. ALGAE

Species : other aquatic plant: Common duckweed, *Lemna minor*
Endpoint : growth rate
Exposure period : 96 hour(s)
Unit : mg/L
Method : Wang, W. 1986
Year : 1988
GLP : No data
Test substance : Barium chloride dihydrate ($BaCl_2 \cdot H_2O$)
Remarks : During a 19-month study period, 59 samples were collected from 18 sample stations; 10 in the state of Illinois and 8 in neighboring states. Four stations were lake stations, three were on major rivers (Illinois, Mississippi and Missouri Rivers); the remainder were on small to medium-sized rivers. Every station was sampled at least twice and one station, Illinois River at Peoria, was sampled 13 times.

Using the surface grab method, 45 L of water was sampled and delivered to the laboratory within 24 hours of collection and immediately processed. The toxicity tests were usually completed within 2 weeks.

The duckweed culture, *L. minor*, was originally collected from the field and has been maintained in the laboratory for more than five years.
The duckweed tests were conducted in jars. A series of barium solutions were prepared in concentrations of 400, 220, 121, 67, 37, 20, and 11 mg barium/L using reagent grade barium chloride. Determination of barium, made using an atomic absorption spectrophotometer, showed barium content was 95 % of nominal. The concentrations were based on preliminary work which showed that they were widely applicable in many water samples. Each jar contained 150 mL of water sample or control (either water control (deionized water) or sample control) and 150 mL of plant nutrients. Thirty fronds, or 15 colonies of duckweed test specimens ware added to each jar and a watch glass used to cover it. Constant illumination was provided by cool-white fluorescent lights at 6456 lux. Temperature was maintained at 25 – 28 °C and the incubation time was 96 hours. At the end of incubation, the number of fronds was counted. The net increase in the number of fronds was an indication of duckweed growth.

Table. Water quality of test samples.

Station	No. of sample	pH	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Tutbidity (NTU)	SO_4 (mg/L)
Beaucrop Creek	2	7.64 – 7.77	89 –116	274 – 400	50 – 114	246 – 352
I River	2	8.0 – 8.10	136 – 214	245 – 320	6 – 70	37 – 54
Fox River	2	8.13 – 8.29	214 – 227	290 – 318	17 – 26	63 – 65
Hayes Creek	2	6.32 – 7.25	10 – 15	37 – 38	311	21 – 22
Horseshoe Lake	2	6.92 – 7.63	46 – 73	54 – 78	11 – 21	2 – 4
Illinois River	13	7.85 – 8.16	158 – 236	232 – 364	33 – 105	81 – 110
LaMoine River	2	7.80 – 8.06	168 – 177	252 – 257	14 – 16	57 – 58
Horseshoe Lake	5	7.95 – 8.12	108 – 115	140 – 146	50 – 137	23 – 63
Lake Michigan	3	7.32 – 7.78	40 – 53	84 – 87	29 – 54	48 – 50
Rend Lake	2	7.95 – 8.08	186 – 210	185 – 298	54	59 – 84

Sangamon	3	8.08 – 8.26	186 – 194	237 – 242	3 – 4	34 – 36
River	3	7.85 – 8.15	182 – 207	308 – 311	13 – 16	90 – 110
Lake Geneva	3	7.57 – 8.09	50 – 160	82 – 256	70 –	12 – 57
Kankakee River	3	7.95 – 8.12	164 – 188	225 – 265	109	101 – 134
Mississippi	3	8.05 – 8.32	114 – 236	160 – 310	38 –	34 – 61
River	3	7.30 – 7.96	50 – 95	80 – 129	258	5 – 32
Rock River	3	7.48 – 8.27	90 – 227	126 – 314	8 – 28	12 – 51
Salt River	3	7.82 – 8.34	156 – 224	244 – 325	16 – 246	62 – 78
Skunk River					57 –	
Wabash Rive					414	
					26 – 156	

Results : The pH of the great majority of samples was within the range 7 – 8.

Water controls and sample controls were pooled together. The mean number of duckweed fronds ± SD (standard deviation) was 65 ± 12 and 73 ± 10, respectively. There was a significant difference ($p < 0.01$) in mean values.

Barium toxicity data were calculated on the basis of sample controls. Water controls were used for quality assurance. Extreme high or low values were repeated.

Seven tests were conducted for barium toxicity to duckweed in plant nutrient medium. Concentrations used ranged from 5.5 to 200 mg barium/łL. The 50 % inhibition concentration (IC_{50}) was 25 mg/łL and the 95 % confidence limit was 18 – 33 mg/łL.

Barium toxicity results in enriched water samples for the Illinois River at Peoria, which was sampled 13 times are summarized as IC_{50} (mg/łL) values below:-

Illinois river:- 280, > 400, > 400, > 400, > 400, > 400, 333, 265, 400, 300, > 400, 232, and 326.

In the six samples with IC_{50} > 400 mg/łL, 400 mg/łL caused 46, 37, 29, 25, 24, and 46 % growth inhibition.

Barium toxicity results in enriched water samples for the remaining sites, are summarized as IC_{50} (mg/łL) values of the nominal concentration below (mean or individual values, when mean could not be calculated):

Beaucrop Creek: - > 400, > 400
I River: - 314
Fox River: - 246
Hayes Creek: - 102
LaMoine River: - 310, > 400
Horseshoe Lake: - 107
Lake Michigan: - 120
Lake Geneva: - 137
Rend Lake: - 175
Sangamon River: - 330, > 400
Kankakee River: - 355
Mississippi River: - 125
Rock River: - 386, 331, > 400
Salt River: - 103
Skunk River: - 199
Wabash River: - 265

The Beaucrop Creek samples taken in December 1984 and March 1984 exhibited 0 and 6 % growth inhibition, respectively, when 400 mg/IL barium was added.

The data suggest, in general, lake water samples with a relatively narrow range of mean IC_{50} values (107 – 175 mg/L) showed a more consistent response to barium toxicity than river water samples in which the mean IC_{50} values ranged from 102 to well in excess of 400 mg/L.

An attempt was made to correlate the barium IC_{50} and sulfate content of the sample. A linear relationship with a coefficient of determination of 0.68 (n-39) confirmed that barium toxicity is modified by sulfate content. Humic acid and other unknown factors may also affect barium toxicity.

Data from this study suggest that barium toxicity is highly dependant on site-specific water quality characteristics. The 5mg/L barium (total) quality standard is considered appropriate to protect common duckweed in all waters tested.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

Flag : Critical study for SIDS endpoint

21.01.2005 (81)

Species : *Chlorella vulgaris*
Endpoint : Growth rate
Exposure period : 3 to 4 month
Unit : mg/L
NOEC : 80
LOEC : 160
Analytical monitoring : No
Method : L.E. den Dooren de Jong, 1965
Year : 1965
GLP :
Test substance : Other TS: Barium chloride, analytical grade
Remaks : - *Test organisms*
Laboratory culture: the collection of the Laboratory of Microbiology, Technological University, Delft
Method of cultivation: sterilization by heating at 110 °C for 20 min
Cultivation took place at room temperature in daylight at a window situated on the Nth.
- *Test conditions*
Temperature: room temperature
Mineral media chemistry: 0.05 % K_2HPO_4, 0.05 % KH_2PO_4, 0.05 % $(NH_4)_2SO_4$, 0.05 % KNO_3, copper-free distilled water, 20 % of which was replaced by activated-carbon-treated tapwater or well-water.
pH: below 7

50 mL of the mineral medium described above was brought into 150 mL Erlenmeyer flasks. The medium was supplemented with 0 (control), 0.004, 0.008, 0.012, 0.02, 0.04, 0.08, 0.12, 0.2, 0.3, 0.4, 0.8, 1.2, 2, 3, 4, 10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 240, 280, 320, 360, 400, 800, 960, and 1200 mg/L of the metal sa;t to be investigated.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

21.01.2005 (41)

4.4 TOXICITY TO MICROORGANISMS E.G. BACTERIA

4.5.1 CHRONIC TOXICITY TO FISH

Type : Static renewal tests
Species : rainbow trout, embryos and larvae
Exposure period : 4 days
Unit : mg/L
LC_{10} : 9.5
Method : Birje, W.J., Black, J.A. and Ramsey. B.A., 1981
Year : 1981
GLP : no data
Test substance : Barium (Paper does not state which salt of barium was used.)
Remarks : Static renewal method used for testing. Fertilized eggs were deposited in deep petri dishes (400 – 600 mL capacity) and exposure continued through 4 – 8 days post hatching. Sample size usually about 100 eggs per dish for both experimental and control populations. Toxicant and dilution water changed at regular 12 hour intervals. Depending on toxicity and solubility stock solutions were generally prepared daily at 10 – 1,000 mg/L. Tests normally conducted using 5 – 10 exposure concentrations, and 2 – 4 replicates. Exposure chambers were aerated to maintain saturation oxygen concentrations. Test conditions, including oxygen, pH and water hardness were monitored. Toxicant concentrations were either calculated from those of the analyzed stock solutions or analyzed directly from test water aliquots taken at the beginning of the 12 hour renewal interval.

Only eggs of high viability were used and control survival normally averaged 80 % or more. Log-probit analysis was applied to combine frequencies of embryo-larval mortality and tertogenesis to determine the concentrations which produced 10 % (LC_{10}) and 1 % (LC_1) control-adjusted impairment of test population with 95 % confidence limits.

Results : Barium LC_{10} 9.5 mg/L
LC_1 2.8 mg/L
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag : Critical study for SIDS endpoint
21.01.2005 (8)

Type : Flow through
Species : *Austropotamobius pallipes pallipes*
Exposure period : 30 days
Unit : mg/L
LC_{50} : 39
Method : The American Public Health Association
Year :
GLP :
Test substance : Barium chloride dihydrate ($BaCl_2 \bullet H_2O$)
Remarks : - *Test conditions*
Temperature: 15 – 17 °C
pH : 7.0
Results :
Reliability : (2) Reliable with restrictions
2g – Data from handbook or collection of data
Flag : Critical study for SIDS endpoint
21.01.2005 (82)

Type : Flow through
Species : *Orconectes limosus*
Exposure period : 30 days
Unit : mg/L

LC_{50}	:	59
Method	:	The American Public Health Association
Year	:	
GLP	:	
Test substance	:	Barium chloride dihydrate ($BaCl_2 \bullet H_2O$)
Remarks	:	- *Test conditions* Temperature: 15 – 17 °C pH : 7.0
Results	:	
Reliability	:	(2) Reliable with restrictions 2g – Data from handbook or collection of data
Flag	:	Critical study for SIDS endpoint

21.01.2005 (82)

4.5.2 CHRONIC TOXICITY TO AQUATIC INVERTEBRATES

Type	:	Static
Species	:	*Daphnia magna*
Exposure period	:	21 days
Unit	:	mg/L
LC_{50}	:	13.5
Analytical monitoring	:	Yes
Method	:	K.E.Biesinger and G.M.Christensen, 1972
Year	:	1972
GLP	:	No data
Test substance	:	Other TS: Barium chloride dihydrate ($BaSO_4 \bullet 2\ H_2O$, CAS No. 10326-27-9), purity = American Chemical Society reagent-grade chemicals
Test conditions	:	- *Test Organisms* Supplier: a laboratory clone originally obtained from the University of Michigan. Age: 12 ± 12 hr old 5 daphnids were placed in 200 mL of water in a 250 mL beaker. Four beakers were used with a total of 20 animals for each experimental and control condition for each test. - *Test Conditions* Dilution water source: Lake Superior water Water chemistry: Total hardness – 45.3 mg/L, Alkalinity – 42.3 mg/L Chloride – 1.2 mg/L, Sodium – 1.1 mg/L, Calcium – 13.7, Magnesium – 3.1 mg/L, Potassium – 0.5 mg/L, Strontium-0.02 mg/L, Barium – 0.01 mg/L, Iron – 0.02 mg/L pH: 7.4 – 8.2 Temperature: 18 ± 1 °C Light: 16-hr photoperiod, Light intensity: 115 ft-c Dissolved oxygen concentrations in test containers were near saturation at all times.There was no feeding during the test. Results were statiscally evaluated with the method of Litchfiedl and Wilcoxon (1949).
Results	:	16 % reproductive impairment was observed at 5.8 mg/L and 50 % reproductive impairment was observed at 8.9 mg/L.
Reliabilities	:	(2) Reliable with restrictions 2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.
Flag	:	Critical study for SIDS endpoint

21.01.2005 (9)

4.6.1 TOXICITY TO SEDIMENT DWELLING ORGANISMS

4.6.2 TOXICITY TO TERRESTRIAL PLANTS

4.6.3 TOXICITY TO SOIL DWELLING ORGANISMS

4.6.4 TOX. TO OTHER NON MAMM. TERR. SPECIES

Species : *T. Putrescentiae* (Mites)
Exposure period : 17 days
Test substance : Barium carbonate ($BaCO_3$)
Test conditions : - Test Organisms
Sex: virgin female and male
Supplier: the Plant Protection Institute in Agriculture University of Warsaw
T. Putrescentiae were reared in special rearing cells.
- Test Conditions
The diets prepared according to the following to the following way served as a food for mites.

Barium carbonate was dissolved in distilled water and then the milled wheat germ was added. After mixing and slow drying in the oven at 40 – 50 °C, this diet was again thoroughly ground.

Remarks : A screening method was used to determine the degree of toxicity of barium carbonate added to ground wheat germ. Inert tritonymphs of *T. putrescentiae* were separately placed for one week in rearing cells supplied with a test diet. Virgin males and females which emerged from the inert tritonymphs were paired and placed into cages for another ten days. After this, the number of eggs and mortality were recorded. The viability of eggs was calculated by the observation of the number of larvae hatched out of 100 eggs from each test. The mites were maintained on the diet for a total of 17 days.

Results :

Conc. (%)*	Number of eggs (Mean +/- SD)	Egg viability(%)
6.0	0.0+/-0.0	--
3.0	3.2+/-3.2	67
1.5	80.8+/-25.6	100

* Concentration in feed.
Control values not reported

Barium carbonate added to ground wheat germ at 6 % concentration caused white spots inside the bodies of mites. Mortality of mites feeding on this diet was high: 25 % and 90 % of the mites were dead after 7 and 17 days, respectively. Egg production by female was completely inhibited. With the 3 % diet, mortality rate was also high (25 %, day not given in report) and low fecundity of mites was observed. Both males and females on this diet were normal in appearance, but smaller in size compared to controls.
Post-embrional development of these mites was possible at least up to the tritonymph stage.

Fecundity of mites feeding on the 1.5 % diet was half of controls. The diet did not affect mite longevity.

Barium carbonate is in the publication classified as very toxic to mites.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

Flag : Critical study for SIDS endpoint
21.01.2005 (33)

4.7 BIOLOGICAL EFFECTS MONITORING

4.8 BIOTRANSFORMATION AND KINETICS

4.9 ADDITIONAL REMARKS

5.0 TOXICOKINETICS, METABOLISM AND DISTRIBUTION

In Vitro/in vivo : *In vivo*
Type : Distribution
Species : Rat
Number of animals
  Males : 162
  Females :
Doses
  Males : 10 mg of ^{131}Barium per liter; 0.5 mL/100 g body weight (equivalent to 5 ~~u~~µg ^{131}Barium/100g body weight).
  Females :
Vehicle : other: 0.8 M solution of sodium carbonate, adjusted to pH 7 with concentrated HCl.
Route of administration : other: intubation
Method :
Year : 1983
GLP : no data
Test substance : ^{131}Barium chloride, ^{131}barium carbonate and ^{131}barium sulfate
Remarks : Male Sprague Dawley rats weighing 250 – 300 g were maintained on a diet of less than 1 mg Barium/kg of food for at least 1 month prior to the experiment.

The dose of ^{131}Barium was constant for the Barium cationion; 5 µg/100 g body weight (0.5 mL/100 g body weight). pH of all solutions was 7.0.

Fasted rats. Overnight fasted rats (24 hours) were administered 5 µg/100 g ^{131}barium as the chloride (10 mg/L; 0.5 mL/100 g), by intubation. Rats (6 per time point) were sacrificed at 2, 15, 30, 60, 120, and 480 minutes after intubation; 200 Ul of blood was sampled and eyes were collected.

Ad lib fed rats received 5 µg/100 g ^{131}barium as sulfate, chloride or carbonate (10 mg/L solutions; 0.5 mL/100 g). Rats (6 per time point) were sacrificed at 2, 5, 10, 20, 30, 60, 120 minutes and 24 hours after intubation; 200 Ul of blood was sampled and eyes were collected. The final sampling time for carbonate administration was 60 min; for sulfate administration was 120 min; and for chloride administration was 24 hours. At the 24 hour sampling point (chloride only) whole heart, one lobe of the liver, both kidneys and the rostral thigh muscle were removed.

Radioactivity content of all samples was counted using an auto-gamma scintillation spectrometer. All counts were adjusted for decay.

Results The data for the ^{131}barium chloride and ^{131}barium carbonate are summarized here.

Following administration of ^{131}barium chloride, blood levels of radioactivity rose rapidly and were peaked at 15 minutes in fasted rats and 60 minutes in rats fed ad lib. Maximum blood levels were higher in fasted rats (25 % higher) compared to fed rats. Blood levels declined there after and at 480 minutes, in fasted rats, the levels were 50 % of maximum. The rate of decline was slower in fed rats and from 60 minutes radioactivity levels were higher than those in fasted rats.

Fed rats dosed with ^{131}barium carbonate accumulated radioactivity in blood at a similar rate to ^{131}barium chloride but to a lesser extent. Peak levels measured at 60 minutes (last sample time) were 40 – 50 % of the radioactivity levels following administration of ^{131}barium chloride The highest rate of radioactivity accumulation in eyes was recorded for fasted rats receiving ^{131}barium chloride; radioactivity levels increased linearly over 30 minutes (no values reported for later time points). In fed rats, radioactivity levels in the eye increased linearly over the first hour for both carbonate and chloride. Thereafter the rate of increase slowed such that radioactivity levels were plateau over 2 – 24 hours for rats that received ^{131}barium chloride. There were no samples taken beyond 60 minutes for ^{131}barium carbonate.

Comparing radioactivity levels in the eyes with that in blood following administration of ^{131}barium chloride show that by 60 minutes, eye levels of radioactivity increased (from below blood levels of radioactivity) to twice the radioactivity levels in blood. The levels in both eye and blood plateau over 2 – 24 hours and a three fold difference is maintained over 24 hours. Eye levels of radioactivity following administration of ^{131}barium carbonate increased to maximum at 60 minutes at a rate that was approximately 50 % of that for ^{131}barium chloride; maximum levels were approximately 40 % of those following administration of ^{131}barium chloride.

24 hour tissue concentrations of radioactivity, following administration of ^{131}barium chloride to fed rats, ranked in the order heart > eye > skeletal muscle > kidney > blood > liver the approximate levels were: - Values are (CPM/g tissue)/(CPM administered/g body weight)

Heart	2.05
Eyes	0.70
Skeletal muscle	0.64
Kidney	0.50
Blood	0.25
Liver	0.18

^{131}Barium carbonate was absorbed to a lesser extent than ^{131}barium chloride. The blood and eye levels of radioactivity indicate that distribution although less extensive for the carbonate salt, would be expected to be similar for barium chloride and barium carbonate. Tissue distribution at 24 hours indicates that barium is concentrated in some tissues (heart > eye > skeletal muscle > kidney) compared to blood. The lower absorption rate for ^{131}barium carbonate may be due, in part, to the large buffering capacity of the dosing vehicle, 0.8M $NaHCO_3$ pH 7.0. This may prevent stomach hydrochloric acid mediated conversion to barium chloride.

Reliability : (2) Rreliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

Flag : Critical study for SIDS endpoint

21.01.2005 (46)

In Vitro/in vivo : *In vivo*
Type : Distribution
Species : Rat
Number of animals
Males : 0
Females : 20
Doses
Males :
Females : See remarks
Vehicle : other: solution or resuspension in distilled water.
Route of administration : intramuscular injection
Method :
Year : 1973
GLP : no data
Test substance : ^{133}barium radioisotope of barium chloride, barium carbonate, barium sulfate, and fused clay.
Remarks : Four groups of five female rats were injected with each of the following

forms of ^{133}barium.

Fused clay (resuspension)
0.0007 mg and 4 µCi barium/rat (total solid 0.008 mg/rat).
Aerosol AMAD (activity median aerodynamic diameter) 2.2 µm.

Barium chloride (solution)
0.009 mg and 4 µCi barium/rat (total solid 0.015 mg/rat)
AMAD, not applicable to solution.

Barium carbonate (resuspension)
0.060 mg and 2 µCi barium/rat (total solid 0.090 mg/rat)
AMAD 0.8 um.

Barium sulfate (resuspension)
0.035 mg and 1.5 µCi barium/rat (total solid 0.060 mg/rat)
AMAD 1.0 um

With the exception of the chloride, the material was aerosolized with a nebulizer, collected on a membrane filter and re-suspended in distilled water. Suspensions were accomplished by ultrasonification of the collection filter. The aerosol was characterized for size distribution and this was assumed to remain the same for the resuspension.

Injection of 0.5 mL of the resuspension (solution) was made intramuscularly into the right hind leg of the female rats (180 to 200 g body weight). The gamma emissions from the ^{133}Barium were detected. Scans of the whole rat were performed on day 0 and throughout the life span of the rat.

Results

Whole-body scanning data showed the amount of radioactivity (corrected for physical decay) in the body decreased exponentially for barium chloride (tri-exponential), carbonate (tri-exponential) and sulfate (bi-exponential). In the case of the fused clay, there was very little reduction in the body burden of radioactivity. By day 280 there was still greater than 90 % of initial dose present in the body. Of the four forms of barium, the barium chloride and carbonate injection sites lost radioactivity most rapidly and in an almost identical manner. Within about 5 days, greater than 50 % of the initial dose had been cleared; by day 40 about 70 % and by day 80 about 75 % of the initial dose had been cleared. There after the rate of loss of radioactivity slowed such that by day 280 about 20 % of the initial dose remained in the body. The sulfate injection site lost radioactivity at a slower rate than the chloride or carbonate, but within 40 and 80 days approximately 50 % and 75 %, respectively, of the initial dose had been cleared. There after the rate of loss of radioactivity slowed, mirroring that observed for the chloride and carbonate. At day 280 there remained in the body about 20 % of the initial dose.

Tissue distribution

Form of 133 barium

Fused clay (death day ranged from 92 to 399)

	% total radioactivity per organ
Femurs	0.3 – 0.5
Humeri	0.2
Injection site	61.9 – 92.8
Carcass*	6.3 – 43.1

Chloride (death day ranged from 95 to 391)

	% total radioactivity per organ
Femurs	8.2 – 9.7
Humeri	4.4 – 4.8
Injection site	0.1 – 0.3
Carcass*	84.9 – 86.8

Carbonate (death day ranged from 55 to 384)

	% total radioactivity per organ
Femurs	8.5 – 9.5
Humeri	3.8 – 4.7
Injection site	0.2 – 0.8
Carcass*	84.9 – 85.9

Sulfate (death day ranged from 61 to 377)

	% total radioactivity per organ
Femurs	4.8 – 9.3
Humeri	2.6 – 4.2
Injection site	0.3 – 36.9
Carcass*	52.9 – 86.1

*(Carcass contains non-injection site muscle, kidney, spleen, liver, gastrointestinal tract, lungs, pelt, and all skeletal tissue, except femurs and humeri).

The long-term component of the radioactivity present in the body is thought to represent long-term skeleton retention, since by day 100 the majority of ^{133}barium had left the site of injection for the three most soluble forms and tissue distribution data (from rats that died or were sacrificed at termination) indicated bone to contain most of the radioactivity.

Two half-lives were estimated; a short-term component for chloride and carbonate of 26 days from the injection site and a long-term component of 460 days from bones (chloride, carbonate, and sulfate).

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

Flag Critical study for SIDS endpoint

21.01.2005 (75)

Type : Metabolism

Remarks : The following are taken from a chapter within a book.

The metabolism of barium in mammals has been studied with radioactive isotopes and shown to be essentially similar to calcium and strontium. The principal physiological activity of barium is stimulation of all types of muscle, irrespective of their innervations.

Mammalian intestinal mucosa is highly permeable to barium ions and is involved in the rapid flow of soluble barium salts into and out of the blood. However, absorption of naturally occurring barium in food is only about 2 % of total dietary intake, because it occurs in bound or insoluble forms.

The average daily human intake of barium is about 1.3 mg (0.65 – 1.7 mg). The human adult body contains 22 mg of barium of which 66 % is present in bones.

Analysis of human tissues reveals the presence of barium in the following: adrenal, aorta, thyroid, lung, muscle, testes, ovary, uterus, and urinary bladder, indicating wide distribution in soft tissue. Mammalian eye contains barium in the iris in concentrations varying from 206 to 1,110 µg/g wet tissue.

Excretion of barium is both fecal and urinary, depending upon route of entry; within 24 hours, 20 % of an ingested dose appears in feces (indicating enterohepatic circulation) and 5 – 7 % is excreted in the urine. However, if an equal dose of a soluble barium salt is injected, urinary excretion is higher. Except for lungs and aorta, there is no total accumulation of barium with human age. Barium is found in new born babies at concentrations higher than in adults; it crosses the mammary and placental barriers.

There is no conclusive evidence for any enzymatic, osmotic, or electrochemical function for barium in mammalian tissue. However it appears to have structural function because of its irreversible lodgment and retention in bone and the presence of barium in the iris suggests a special function.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
Flag : Critical study for SIDS endpoint
21.01.2005 (76)

Type : Distribution
Remarks : Barium is not an essential element in human tissues. Not many data are available, but the following averages have been found:

Bone	4.1 – 29 µg Ba/g
Blood	41 – 95 µg Ba/L
Kidney	1.3 – 20 µg Ba/g
Liver	0.2 – 10 µg Ba/g
Spleen	0.6 – 12 µg Ba/g.

Assuming an average of 70 kg as human body weight, barium content has been estimated to be about 16 mg.

Barium forms a protein adduct in serum and is deposited in bone (65 %). The half-life in bone has been estimated to be 50 days.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data.
Flag : Critical study for SIDS endpoint
21.01.2005 (22)

Type : Distribution
Test conditions : Data relevant to Barium is summarized below, although the publication also includes data on calcium, strontium, and radium.

The study was performed in a healthy 60 year old man (main author of the publication). The ^{133}Ba was administered in succession over a 10 week period with a 2 – 3 week interval between consecutive injections. Plasma concentrations were measured for 7 days and urinary and faecal excretions for 1 month or more following intravenous administration. A sample containing 2.25 µCi of ^{133}Ba radioactivity was made up to 10 mL in isotonic saline. 4 mL of the sterilized solution was administered i.v.; the remainder was used to prepare standards.

Plasma was analyzed using a gamma-ray spectrometer. The count-rate in the principal photopeak of ^{133}Barium from 10 mL of plasma was compared to the count-rate from a standard solution of the given radionuclide.

Urine collected for the first 7 or 8 days was acidified and quantified using gamma-ray spectrometry. Thereafter urine samples were dried and ashed prior to quantification.

Fecal samples were collected daily, dried and thermally ashed prior to quantification using gamma-ray spectrometry.

Radioactivity in saliva (2h and 6h) and seminal fluid (6h) was also quantified.

Results : *Plasma, saliva and seminal fluid concentrations*:

Time post admin.	% of injected dose per liter of plasma.
10 min	6.94
3 h	1.15
12 h	0.335
25 h	0.119
49 h	0.082
75 h	0.035
97 h	0.022
145 h	0.012

Saliva contained 0.33 and 0.22 % of injected dose per liter of fluid at 2 and 6 hours, respectively. Seminal fluid contained 0.81 % of injected dose per liter of fluid at 6 hours.

Urinary excretion:

Time (days)	% of injected dose (cumulative)
0 – 0.25	4.44
0.25 – 0.5	5.75
0.5 – 1	6.78
1 – 2	7.53
2 – 3	7.88
3 – 21	9.06
22 – 28	9.13

Fecal excretion:

Time (days)	% of injected dose (cumulative)
1	22.20
2	51.00
3	65.02
4	67.68
5	71.45
6	74.95
7	no excretion
8	77.41
9	78.44
10 – 13	80.36
14 – 16	81.20
17 – 21	81.98
22 – 70	84.91

The total urinary: fecal ratio excretion for ^{133}Ba 21 days after administration was 1:9.

Test substance : Radioactive ^{133}Ba; The salt was not mentioned.

Conclusions : *Maximum tissue content*
Tissue uptake, derived as, tissue uptake = 100-(urinary excretion + faecal excretion + activity in the total extracellular fluid space)

Hours after admin.	Tissue(%)
0.5	45.6
1	52.7

2	53.6
5	46.6
10	40.9
24	29.0
36	25.6
48	23.0

At about 1½ hours, the tissue content reached the maximum of 55 %.

Ratio to the total body content
The ratio of the calculated tissue content to total body content is 0.38 %. Considering the tissue content of Ba(0.095 mg) and the total body Ba(30 mg).

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

Flag : Critical study for SIDS endpoint

21.01.2005 (23)

Type : other: summary of human barium carbonate toxicity symptoms and treatment

Remarks : The following are summarized in a section on barium toxicity and treatment.

Pathophysiology.
Barium initially stimulates striated, cardiac and smooth muscle and depresses serum potassium which is forced intracellularly. Subsequent muscle weakness may result from a direct depolarizing effect and neuromuscular blockade.

Clinical presentation.
After ingestion of acid soluble salts, humans develop severe gastrointestinal irritation followed by muscle twitching, progressive flaccid paralysis and severe hypokalaemia and hypertension. Respiratory failure, renal failure and occasionally cardiac dysrhythmias may result from acute ingestion.

Laboratory.
Peak barium levels occur within 2 hours of ingestion in an overdose. Normal barium levels do not exceed 0.4 µg/mL. Following an overdose, barium levels decline rapidly with an elimination half-life of 3 hours. Hypokalaemia after overdose maybe severe (below 2.0 mEq/L). Magnesium levels remain normal.

Treatment.
1. Start usual measures of decontamination.
2. Use sodium sulfate as cathartic.
3. Add 5 to 10 g sodium sulfate to lavage solution or as fluid supplement to syrup of ipecac since the sulfate salt of barium is insoluble.
4. Monitor cardiac rhythm and serum potassium to establish trend over first 24 hours. Large doses of potassium may be required to correct hypokalaemia.
5. Administer fluid replacement but monitor the urine and serum evidence of renal failure.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data

Flag : Critical study for SIDS endpoint

21.01.2005 (48)

Type of experience : Human – Occupational exposure

Route of administration : Inhalation
Year : 1992
Remarks : Three groups of welders using such electrodes and wires with a high Ba content in an experimental study under controlled condition were investigated.

Study design
The welders had not used Ba-containing consumables for at least 10 days before the investigation started, and most of the welders had never used such electrodes
Group A: Eight welders performed arc welding with Ba-containing stick electrodes. No ventilation system were used.
Group B: Five welders performed arc welding with Ba-containing self-shielded flux cored wires. No ventilation system were used.
Group C: Five welders performed arc welding with Ba-containing self-shielded flux cored wires with ventilation system.

Materials
Stick electrodes: The welding fumes contained 37.3 % of Ba, about 80 % of which was soluble in hydrochloric acid.
Self-shielded flux cored wires: A Ba content of 31.7 % was found in the fumes, 99% of which was soluble in hydrochloric acid.

Exposure period
In week 1, all welders performed welding with Ba-free consumables during Thursday and Friday. In week 2, welding was performed with Ba-containing stick electrodes and wires. After a free weekend, welding with Ba-free consumables was again carried out on Monday of week 3.

Measurement of the external exposure : total welding fumes and soluble Ba
Assessment of the internal exposure : biological monitoring of plasma and urine spot samples, medical history taking, thorough clinical and neurological investigations, ECG (limb and percordial leads), continuous 24-h ECG (two channels), plasma electrolytes (sodium, potassium, magnesium, and total and ionized calcium)
Whloe blood was checked for pH, standard bicarbonate, and base excess. The activities of tubular renal enzymes [N-acetyl-β-D-glucosaminidase (NAG) and alanine aminopeptidase (AAP)] were measured in urine spot smaples.

Results *External exposure*
The remarkable number of measurements exceed the TLVs for overall welding fumes (5 mg/m3) and soluble Ba (0.5 mg/m3).

Table. Median values and range of external exposure

	Stick electrodes	Flux cored wires without exhaust system	Flux cored wires with exhaust system
Total fume (mg/m3)	13.2 n.d. – 151.4	12.3 4.2 – 42.1	2.6 0.6 – 5.3
Barium (mg/m3)	4.4 0.1 – 22.7	2.0 0.3 – 6.0	0.3 0.1 – 1.5
Content of Ba in total fume (%)	26.1 4.0 – 84.7	14.4 6.2 – 35.9	12.4 6.2 – 56.5
Average consumption of consumables per day and welder[a]	98 – 106	6.5 – 7.5	5.8 – 7.1

[a] Stick electrodes: modal values per day and subject (pieces). Wires: arithmetic average per day, calculated from the consumption over 1 week per welder (kg)

Internal exposure

Table. The median concentrations of Ba in urine and plasma during week 2

	Stick electrodes	Flux cored wires without exhaust system	Flux cored wires with exhaust system
Urine (ug/g creatinine)	89.1 9.5 – 370.6	77.3 18.5 – 287.9	49.2 3.1 – 179.5
Plasma (ug/L)	24.7 4.1 – 63.4	16.6 4.5 – 74.0	4.4 1.2 – 7.9

Medical findings
There were some minor changes in subjective health status.
Clinical labortory findings
No welder showed any trend during the Ba exposure, but hypokalemia may have occurred as a result of the Ba exposure. Potassium levels of plasma dropped, mainly in group A and group C, with minimum median values of 3.7 and 3.6 mmol/L respectively. These differences were not significant.
Electrocardiography
Almost all ECGs showed regular curves. Neither any trend during week 2 nor any differences before and after shifts could be seen. No hypokalemic transformation of the T waves occurred.

Reliability : (2) reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment.

29.04.05 (83)

Type : other: trace elements in human bone

Remarks : A method is described for the determination of strontium and barium in human bone by radio-activation analysis. Only the barium data are presented here.

Specimens of various bones were collected from autopsies held in different parts of Britain. Material from 'normal' bodies were selected whenever possible. Samples of bone were generally taken from the diaphyses of long bones or shafts of ribs.

Concentration (µg/g of ashed bone; ppm) of barium in human bones

Age	n	Range	Mean (±SD)
0 – 3 months	7	1.9 – 13.0	7.0 (4.0)
1 – 13 years	9	2.1 – 21.0	7.6 (7.0)
19 – 33 years	9	4.3 – 7.9	5.1 (0.12)
33 – 74 years	10	3.7 – 17.3	8.5 (4.0)

Repeated determination of barium concentration in five bone samples were made to estimate reproducibility. Mean results varied not more than 5%.

Concentration of barium in bones did not vary with human age. There was no evidence of a relationship between barium concentration and disease or the sex of individuals.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (68)

Type : Adsorption

Remarks : Analysis was carried out for 66 minor inorganic elements of whole enamel samples obtained from 28 bicuspid teeth (< 20 years). Each sample was analyzed separately using spark source mass spectroscopy technique. 35 elements were present in enamel in quantifiable limits and 31 elements, if present, were below the limits of detection.

Teeth were collected from 24 communities located in 16 States in the United States. The communities were selected on the basis of their geographic location, the chemical composition of their water supply, the surrounding soil type, or the known caries prevalence. In addition, teeth were chosen from individuals from other areas with particularly low or high dental caries history. Hence, the enamel selected for analysis represented a wide range of environments.

Barium (µg/g dry weight) was found to be present in moderate concentration:

median	3.4
mean	4.2 ± 0.6
minimum	0.8
maximum	13

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (43)

5.1.1 ACUTE ORAL TOXICITY

Type : LD_{50}
Value : 419 mg/kg (male), 408 mg/kg (female)
Species : Rat
Strain : Sprague-Dawley derived CD rats
Sex : male/female
Number of animals :
Vehicle : other: deionized water
Doses : 60 – 960 mg/kg using 1.2 % and 4.8 % solutions
Method :
Year : 1988
GLP : no data
Test substance : Other TS; Barium chloride, purity = 99+ %, Sigma-Aldrich, Lot No. 20245L
Remarks : These data are reported in a publication on short-term (1-day summarized bellow) and 10-day (summarized in Section 5.4) toxicity.

No data are given on specific methodology or number of animals used.

The study aim was to determine the median lethal dose in male and female rats gavaged with barium chloride. A dose range of 60 to 960 mg/kg was administered using solutions of 1.2 % or 4.8 % concentration.

The LD_{50} and 95 % confidence interval limits are

male 419 (532 – 499) mg/kg barium chloride
female 408 (342 – 487) mg/kg barium chloride

Approximately 90 % of deaths occurred within 5 hours of administration. Primary necropsy findings included a hemorrhagic area in the stomach and inflammation on the intestines.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment
Flag : Critical study for SIDS endpoint

21.01.2005 (10)

Type	:	other: single dose study
Value	:	
Species	:	Rat
Strain	:	Sprague-Dawley derived CD rats
Sex	:	male/female
Number of animals	:	80
Vehicle	:	other: deionized water
Doses	:	30, 100, and 300 mg/kg
Method	:	
Year	:	1988
GLP	:	no data
Test substance	:	Other TS; Barium chloride, purity = 99+ %, Sigma-Aldrich, Lot No. 20245L

Remarks : This study is divided into a 1-day (summarized here) and 10-day study (summarized in Section 5.4).

Male and female rats were randomized into groups consisting of 10 males and 10 females per group.

Barium chloride was dissolved in deionized water to give 0.75 % and 1.5 % solutions. The solutions was prepared on day of administration and delivered at a volume of 4.0 (0.75 % solution, 30 mg/kg), 6.7 (1.5 % solution, 100 mg/kg), and 20.0 (1.5 % solution, 300 mg/kg) mL/kg. Vehicle control was given at 20 ml/kg.

The rats were deprived of food but had free access to water for 16 – 18 hours prior to being dosed between 08:00 and 10:00. After dosing, animals were observed continuously for approximately 5 hours. Body weights were determined initially and at termination (24 hours after dosing). Animals were subject to necropsy. Gross pathological examination was performed, followed by removal and weighing of selected organs (brain, liver, spleen, lungs, thymus, kidneys, and testes or ovaries). Histopathological evaluation was performed on liver, kidney, and heart tissue. Urinalysis and various hematologoical and clinical chemistry parameters were determined.

All data were subjected to an analysis of variance and test for homogeneity and a Dunnett's t-test. Nonhomogeneous data were subjected to Wilcoxon Rank Sum Test. Those values that differed from the vehicle group at $p < 0.05$ were considered insignificant.

Results : *Body weight changes and mortality*.
Body weights of male and female rats exposed to 30 – 100 mg/kg barium chloride increased in the range 6.0 to 9.4 %.
However, bodyweights in male and female rats in the 300 mg/kg dose group decreased 7.4 and 2.8 %, respectively. There were no significant signs of intoxication. No deaths occurred at dose levels of 30 and 100 mg/kg. At 300 mg/kg barium chloride, 8/10 male and 7/10 female rats died within 24 hours. Changes observed at necropsy in a majority of male rats at 300 mg/kg dose level only, included an ocular discharge, fluid in the trachea and darkened liver. In both sexes, inflammation of the small and large intestines were seen at the 300 mg/kg dose level.

Body and organ weights.
At 30 and 100 mg/kg dose levels, there were no significant differences in body or organ weights from vehicle control in male rats. In female rats, the lung/brain (0.61 ± 0.02) and ovaries/brain (0.07 ± 0.01) weight ratios were significantly lower at 30 mg/kg compared to vehicle control (0.69 ± 0.3 and 0.08 ± 0.01, respectively). At 300 mg/kg, both sexes exhibited.
i) significantly lower body weights (males 181 ± 10 g and vehicle control 217 ± 7 g; females 144 ± 6 and vehicle control 163 ± 3 g),
ii) lower liver/brain weight ratios (males 5.10 ± 0.29 and vehicle control 6.93 ± 0.37; females 5.03 ± 0.33 and vehicle control 5.86 ± 0.21), and

iii) high kidney/body weight ratios (males 1.0 ± 0.05 and vehicle control 0.95 ± 0.03; females 1.08 ± 0.09 and vehicle control 1.04 ± 0.03). At 300 mg/kg dose level, in male rats liver weight (9.25 ± 0.83 g compared to vehicle control 12.58 ± 0.68 g) was significantly reduced.

Clinical chemistry.
Increases seen in SGPT (ALT), SGOT (AST), 5'-nucleotidase, and phosphorous at 30 and/or 100 mg/kg were not dose related. At the 300 mg/kg there were no significant differences in either sex.

Hematology.
There were no significant differences in either sex at dose levels of 30 or 300 mg/kg. In male rats given 100 mg/kg barium chloride, hemoglobin and hematocrit were elevated. There were no significant differences in coagulation data or differential cell count in either sex at any dose level.

There is no data reported on the urinalysis.

The effects on body, liver, and kidney weights after a single dose of 300 mg/kg appear to be related to barium chloride. The differences in lung and ovary weight ratios at 30 mg/kg in females appear not to be compound related since these effects were not observed at higher doses.
: (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment
Flag : Critical study for SIDS endpoint
21.01.2005 (10)

Type : LD_{50}
Value : 200 mg/kg (mouse), 418 mg/kg (rat)
Species/Strain : Mouse, Rat
Test substance : Other TS; Barium cCarbonate
Remarks : Behavioral : Somnolence (general depressed activity), Tetany
Reliability : (4) Not assignable
4b-Secondary literature

04.04.2005 (54)

Type : LD_{50}
Value :
Species/Strain :
Remarks : Oral LD_{50} of barium carbonate in rats 800 mg/kg.
Reliability : (4) Not assignable
4b-Secondary literature
21.01.2005 (47)

Type : LD_{50}
Value :
Species/Strain : Rat
Remarks : Acute oral LD_{50} of barium carbonate in rats 630 – 750 mg/kg.
Test substance : Barium Carbonate
Reliability : (4) Not assignable
4b-Secondary literature
21.01.2005 (59)

Type : LD_{50}
Value : < 400 mg/kg
Species/Strain : Albino mice
Number of animals :
Vehicle :

Doses : 50 – 400 mg/kg
Method : Enteral
Year : 1977
GLP : no data
Test substance Other; $BaCO_3$
Reliability (4) Not assignable
4b-Secondary literature
21.01.2005 (72)

Type : other: LD_{50} and effect on growth.
Value : LD_{50} = 623mg/kg
Species : other: chiken
Strain :
Sex : Male
Number of animals : 40
Vehicle : other: LD_{50} required dose was packed into gelatin capsules
Doses : LD_{50}: - 400, 500, 600, 700, and 800 mg
Method :
Year : 1960
GLP : no data
Test substance : Other; Barium hydroxide
Remarks : Study divided into two section; single dose toxicity (summarized here) and effect on growth (summarized in Section 5.4).

40 male chickens, 7 weeks old, weighing an average of 943 ± 44 g, were used. Barium hydroxide packed into gelatin capsules was placed as far down the ariegate as possible and guided down into the chicken crop by stroking.

Table. Toxicity of a single dose of Barium Chloride

Barium (mg)	Survivors/No. treated
400	7/8
500	5/8
600	4/8
700	2/8
800	1/8

The LD_{50} dose of barium was estimated to be: - 587 ± 147 mg/chicken or 623 ± 156 mg/kg live weight.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment
21.01.2005 (37)

Type : LD_{50}
Value : 118 mg/kg
Species/Strain : Rat
Test substance : Other TS; Barium chloride
Remarks : No effects are given
Reliability : (4) Not assignable
4b-Secondary literature
04.04.2005 (53)

5.1.2 ACUTE INHALATION TOXICITY

5.1.3 ACUTE DERMAL TOXICITY

5.1.4 ACUTE TOXICITY, OTHER ROUTES

Type	:	Acute
Species	:	other: no data
Sex	:	
Strain	:	other: no data
Route of admin.	:	other: intra-tracheal
Exposure period	:	one single dose
Frequency of treatm.	:	
Post exposure period	:	Up to 9 months
Doses	:	50 mg
Control group	:	no data specified
Method	:	
Year	:	1977
GLP	:	no data
Test substance	:	Other TS; Barium carbonate
Remarks	:	This data is presented in a publication which includes studies on rabbits, rats and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes. It is not stated which species was used in the study. Description of the study in the publication followed discussion on a rat study and it would be reasonable to assume that rats were used for the intratracheal (IT) study. 50 mg of barium carbonate dust (no description of dose form) was administered IT.
Results	:	At 3 months after administration, no accumulation of barium carbonate was found in the lungs, but there were signs of early sclerotic changes. At 6 months after administration, sclerosis of lung tissue was highly pronounced; the walls of the large bronchi were sclerosed and showed lymphohistiocytic infiltration, lung tissue was emphysematous with focal peribronchial and perivascular sclerosis, there were signs of collagenation and spread of argyrophil framework. At 9 months after administration, the sclerosis was even more pronounced and assumed a diffuse character. Fibrous pneumonia with necrosis of the mucous membrane in the large bronchi was also developed. The data provided strong evidence for the progressive characteristics of the fibrotic process. The pathlogical opinion can be interpreted as diffuse progressive toxico-chemical pneumosclerosis.
Conclusion	:	The one single dose of barium carbonate dust through the respiratory tract had a toxic effect.
Reliability	:	(4) Not assignable 4b-Secondary literature
Flag	:	Critical study for SIDS endpoint

21.01.2005 (72)

Type	:	Other
Value	:	
Species	:	Dog
Strain	:	other: mongrel
Sex	:	male/female
Number of animals	:	
Vehicle	:	other: isotonic saline
Doses	:	0.5 – 4 µmol/kg/min
Route of admin.	:	i.v. Infusion
Exposure time	:	

Method	:	
Year	:	1971
GLP	:	no data
Test substance	:	Other; $BaCl_2$ (reagent grade) dissolved in isotonic NaCl
Remarks	:	Mongrel male and female dogs weighing between 6 and 22 kg were used in the study. General anesthesia was produced with sodium pentobarbital, 30 mg/kg, i.v. The urinary bladder and femoral artery were catheterized in several experiments to collect urine and measure arterial blood pressure. When respiratory assistance was required, an endotracheal tube was attached to a ventilator. Barium chloride, 2.44 g, was dissolved in 1,000 mL of isotonic sodium chloride, giving a 0.01 M solution. Potassium chloride was dissolved in isotonic sodium chloride to give 100 to 400 Nm solutions. The sequence of infusions and timing of various experiments varied. *Physiologic measurements*. I) Electrocardiogram, lead II. Ii) Arterial pressure, femoral artery cannula. *Distribution of potassium between plasma and red cells*. Blood samples from a femoral artery were collected in heparin-treated tubes after an infusion of isotonic saline and again after an infusion of barium chloride. One aliquot of each blood sample was analyzed for whole potassium and another was diluted 1:20 with distilled water and analyzed for whole blood potassium. Red blood cell potassium concentration was calculated. Potassium concentrations were measured with a flame photometer.
Results	:	*GENERAL OSERVATIONS* In the i.v. infusion of barium chloride, an infusion rate of 1.0 µmol/kg/min was generally used. Higher rates, 4.0 µmol/kg/min, were fatal within a few minutes as a result of respiratory paralysis and ventricular tachycardia. At the lower infusion rate the following was observed, in chronological order: - within 5 minutes, arterial hypertension and premature supraventricular and ventricular contractions, followed by spontaneous skeletal muscle contraction, salivation and later, watery diarrhea. This was followed by generalized muscle twitching, increased respiratory rate and decreased respiratory depth. Electrocardiograph changes became more severe, with multiple premature ventricular contractions. If the infusion were continued, there was a sudden drop in blood pressure and usually flaccid paralysis of skeletal, including respiratory, muscle. At this stage if respiration was assisted, cardiac events consisted of ventricular tachycardia, fibrillation and death could be closely observed. Simultaneous infusion of potassium abolished the skeletal muscle paralysis, the salivation, diarrhea and cardiac toxicity, but not hypertension. *PLASMA POTASSIUM CONCENTRATIONS FOLLOWING BARIUM CHLORIDEINFUSION*. Thirteen dogs were studied. One group of six dogs received isotonic saline (700 mL, 30 min.), potassium levels were measured and then barium chloride infusion was followed by the second potassium level measurement. The second group received only barium chloride. Total barium chloride dose varied from 22 to 154 µg/kg over a period of 20 to 100 minutes. Each of the thirteen dogs had decreased plasma potassium levels, the difference in pre- and post infusion values ranging from 0.31 to 2.1 mEq/L. There was a significant difference between mean plasma potassium values pre- and post barium chloride infusion in both groups; 2.98 ± 0.127 mEq/L and 1.97 ± 0.13 mEq/L, respectively in the saline loaded group and 3.4 ± 0.12 and 2.20 ± 0.19, respectively in the group that

did not receive saline first. There was no apparent correlation between total dose of barium chloride and the degree of potassium level depression.

URINARY POTASSIUM EXCRETION.
Ten dogs were studied. Plasma potassium concentration, urine flow and urinary potassium excretion were compared during isotonic saline infusion (700 mL, 30 min.) and then during barium chloride infusion (0.33 – 2.0 µmol/kg/min for 10 – 100 min.). Plasma potassium levels decreased significantly during barium chloride infusion, but there was no significant change in urine flow or urinary excretion of potassium.

DISTRIBUTION OF POTASSIUM IN PLASMA AND RED CELLS.
Nine dogs were studied. The first six dogs received isotonic saline (700 mL, 30 min.), and then an arterial blood sample was taken. The remaining three dogs did not receive isotonic saline, but a blood sample was taken. All dogs then received barium chloride infusion (0.36 – 2.0 µmol/kg/min for 30 –100 min.). Plasma potassium concentration decreased in all dogs and in 8/9 dogs red cell potassium concentration increased. There was a significant decrease plasma levels, which were 2.87 ± 0.16 and 1.89 ± 0.14 mEq/L, pre and post barium chloride infusion respectively. The increase in red cell potassium was also significant; mean (± SEM) pre- and post-barium chloride infusion values were 5.64 ± 0.32 and 6.46 ± 0.39 mEq/L, respectively.

ARTERIAL BLOOD PRESSURE RESPONSE TO BARIUM CHLORIDE.
An increase in blood pressure was seen within 5 – 10 minutes of start of barium chloride 2.0 µmol/kg/min infusion. The increase subsided 30 – 40 minutes after end of infusion. Each of 24 dogs showed a hypertensive response; the pre- and post-infusion blood pressures for the entire group averaged 138/86 and 204/130, respectively. The response was not prevented or altered by prior or simultaneous infusion of potassium chloride at a rate sufficient to prevent any decrease in plasma potassium. Phentolamine (an alpha-adrenergic blocker) did not prevent barium chloride induced hypertension.

CARDIAC EFFECTS OF BARIUM CHLORIDE AND POTASSIUM CHLORIDE.
Control electrocardiograms were recorded for ten dogs – all were normal. Each received an infusion of barium chloride (0.5 – 2.0 µmol/kg/min, for 25 to 100 min.) until ectopic ventricular contraction was evident in the electrocardiogram. Plasma potassium decreased from a mean of 3.2 to 2.1 mEq/L. Potassium chloride was then added to the infusion solution in amounts sufficient to deliver 30 to 150 µmol/kg/min of potassium. Within 10 minutes the electrocardiogram reverted to normal in 8/10 dogs and to a hyperkalaemic pattern in two dogs (potassium levels greater than 10 mEq/L). These two dogs had received the highest infusion of potassium.

REVERSAL OF POTASSIUM CARDIOTOXICITY WITH BARIUM CHLORIDE.
Six dogs had plasma potassium levels measured and then potassium chloride (20 – 60 µmol/kg/min, 20 – 168 min.) was infused until the electrocardiogram indicated hyperkalemia and plasma potassium levels were 8-11 mEq/L. The dogs were then infused with a solution containing potassium chloride and barium chloride (potassium chloride 20 – 60 µmol/kg/min and barium chloride 1.0 – 2.0 µmol/kg/min, 7 – 40 min.). Within 7 to 40 minutes all electrocardiograms had become normal despite potassium plasma levels remaining elevated (greater than 9 mEq/L) in a couple of dogs, whilst in the remainder of dogs the levels had decreased to normal.

		The authors report that by a process of trial and error they found a solution delivering potassium chloride and barium chloride at 30 and 1 µmol/kg/min, respectively, could be administered for several hours without altering the electrocardiogram or raising the plasma potassium above normal level. The fact that plasma potassium levels remained normal in the absence of urinary loss or diarrhea strongly indicates uptake of potassium by cells. Changing the infusion ratio to less than 30:1 produced barium toxicity and conversely changing the ratio to greater than 30:1 produced hyperkalaemia.
Conclusions	:	The infusion of barium chloride in dogs produced a decrease in plasma potassium concentration and an increase in red cell potassium concentration. Hence the hypokalemia is a result of a shift of potassium from extracellular to intracellular water. Arterial hypertension resulted following infusion of barium chloride and data suggest a direct effect on arteriolar smooth muscle. Potassium effectively abolished myocardial toxicity of barium.
Reliability	:	(2) Reliable with restrictions 2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment
Flag	:	Critical study for SIDS endpoint

21.01.2005 (64)

5.2.1 SKIN IRRITATION

Species	:	other: rat and rabbit
Year	:	1977
GLP	:	no data
Test substance	:	Other TS; Barium carbonate
Remarks	:	This data is presented in a publication which includes studies on rabbits, rats and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes. Experiments (subacute) on rats and rabbits demonstrated local irritant effect of barium carbonate on the skin and mucous membranes. In particular, barium carbonate in a lanolin base applied to rat or rabbit skin caused small ulcers to develop. These disappeared within a month when treatment was discontinued. There is no information on methodology.
Reliability	:	(4) Not assignable 4b-Secondary literature

21.01.2005 (72)

5.2.2 EYE IRRITATION

Species	:	other: rat and rabbit
Year	:	1977
GLP	:	no data
Test substance	:	Other TS; Barium carbonate
Remarks	:	This data is presented in a publication which includes studies on rabbits, rats, and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes. When barium carbonate was introduced into the conjunctival sac, purulent discharge appeared. This was followed by the development of conjunctivitis and slight corneal opacity. This report did not mention

whether the symptoms were reversible or not.

There is no information on methodology.

Reliability : (4) Not assignable
4b-Secondary literature

21.01.2005 (72)

5.3 SENSITIZATION

5.4 REPEATED DOSE TOXICITY

Type : Sub-acute
Species : Rat, mice
Sex : male/female
Strain : F334/N(rat), B6C3F_1(mice)
Route of admin. : Oral (drinking water)
Exposure period : 15 days
Post exposure period : No
Doses : Rats
0, 125, 250, 500, 1,000, and 2,000 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the average daily dose of 0, 10, 15, 35, 60, and 110 mg Ba/kg bw to males and females)

Mice
0, 40, 80, 173, 346, and 692 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the average daily dose of 0, 5, 10, 20, 40, and 70 mg Ba/kg bw to males and 0, 5, 10, 15, 40, and 85 mg Ba/kg bw to females)
Control group : Yes
Year : 1982
GLP : no data
Test substance : Other TS; Barium chloride dihydrate(CAS No. 10326-27-9); J.T. Baker Chemical Company; Lot No. 123120
Test conditions : Age at study initiation: 10 weeks(rat), 11 weeks(mice)
No. Of animals per sex per dose: 5 males and 5 females

Study design
Animals were housed five per cage; available for water and feed. Water consumption was measured twice weekly; clinical findings were recorded once daily; animals were weighted at study intitation, twice a week, and at the end of the study.
Neurobehavioral studies were conducted, and behavioral assessment were performed on each rat at the study intitation and termination. Necropsy was performed on all animals. Organ weights were recorded for brain, heart, right kidney, liver, lung, right testis, and thymus. Blood samples were collected and the following items were measured; hematocrit, hemoglobin, erythrocytes, mean erythrocyte volume, leukocyte count, and differential, barium, sodium, potassium, calcium, and phosphorus. In the highest dose group, histopathology was performed. In addition, the livers from control and treated groups were examined.

Results : Rats
No chemical-related deaths and clinical findings were occured. While final mean body weights of all rats were within 5 % of the controls, the mean body weight gain of male rats receiving 2,000 ppm(31 ± 3 g) was 18 % lower than controls(38 ± 2 g). Water consumption by male and female rats exposed to 2,000 ppm was ≤ 16 % lower than that by the controls during week 2. No significant differences in neurobehavioral and behavioral parameters, organ weights, and hematology parameters were observed.

Mice
No chemical-related deaths and clinical findings were observed. There were no changes in water consumption and the final mean body weights, The liver weights were increased in female mice; the absolute weight at 692 ppm(1.542 ± 0.101 g) compared to the control(1.210 ± 0.033 g), the relative weight at 692 ppm(65.74 ± 2.98 g) compared to the control(55.72 ± 1.22 g). The relative liver weights of 692 ppm males(65.79 ± 1.78 g) was significantly greater than that of control(56.73 ± 1.76 g).

Conclusions : Barium chloride dihydrate produced minimal and biologically insignificant effects in rats and mice at dose of up to test concentration.

Reliability : (1) Reliable without restrictions
1d-Test procedure in accordance with generally accepted scientific standards and described in sufficient detail

21.01.2005 (55)

Type : Sub-chronic
Species : Rat, mice
Sex : male/female
Strain : F334/N(rat), B6C3F_1(mice)
Route of admin. : Oral (drinking water)
Exposure period : 13 weeks
Post exposure period : No
Doses : Rats
0, 125, 500, 1,000, 2,000, and 4,000 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the average daily dose of 0, 10, 30, 65, 110, and 200 mg Ba/kg bw to males and 0, 10, 35, 65, 115, and 180 mg Ba/kg bw to females)

Mice
0, 125, 500, 1,000, 2,000, and 4,000 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the average daily dose of 0, 15, 55, 100, 205, and 450 mg Ba/kg bw to males and 0, 15, 60, 110, 200, and 495 mg Ba/kg bw to females)

Control group : yes
Year : 1983
GLP : no data
Test substance : Other TS; Barium chloride dihydrate(CAS No. 10326-27-9); J.T. Baker Chemical Company; Lot No. 123120
Test conditions : Age at study initiation: 6 weeks(rat and mice)
No. Of animals per sex per dose: 10 males and 10 females

Study design
Animals were housed five per cage; available for water and feed. Water consumption was measured weekly; clinical findings were recorded once daily; animals were weighted at study intitation, once weekly, and at the end of the study.
Neurobehavioral studies were conducted on all rats and mice at 0, 45, and 90 days. Necropsy was performed on all animals. Organ weights were recorded for adrenal gland, brain, heart, right kidney, liver, lung, right testis, and thymus. Blood were collected and the following items were measured;

hematocrit, hemoglobin, erythrocytes, mean erythrocyte volume, mean erythrocyte hemoglobin, mean erythrocyte hemoglobin concentration, platelets, nucleated erythrocytes, leukocyte count and differential, barium, sodium, potassium, calcium, and phosphorus. Histopathology was performed. In addition, cardiovascular studies were performed on each rat at 0, 45, and 90 days.

Results : Rats
Three males and one female in the 4,000 ppm groups died. The final mean body weights and mean body weight gains of all rats at dose 4,000 ppm were significantly lower than the controls. Water consumption by all rats receiving 4,000 ppm was 30 % lower than the controls. No chemical-related clinical signs of toxicity were noted. Serum phosphorus levels of male and female rats received 2,000 and 4,000 ppm were highter than those of the controls. Also, the absolute and relative kidney weights of females received 2,000 and 4,000 ppm and the relative kidney weights of males received 4,000 ppm were significantly greater than those of the controls. Renal tubule dilatation in the outer medulla and the renal cortex occured in all rats exposed to 4,000 ppm, which was the chemical-induced kidney lesions.

Mice
Six males and seven females in the 4,000 ppm groups and one male in the 125 ppm died or were killed moribund. The final mean body weights of male and female mice receiving 4,000 ppm were significantly lower (> 30 %) than those of the controls. Water consumption by male mice in the 4,000 ppm group was 18 % lower than that by the controls, but other exposed groups were similar to the control groups. The absolute and/or relative liver weights of mice exposed to 1,000, 2,000, and 4,000 ppm and the absolute and relative thymus weights of 4,000 ppm mice were significantly lower than those of the controls. Nephropathy –tubule dilatation, regeneration, and atrophy- and atrophy of the thymus and spleen were observed in male and female mice receiving 4,000 ppm.

Conclusions : The no-observable-effect concentration for barium chloride dihydrate in drinking water for rats and mice was estimated to approximately 2,000 ppm based on the final mean body weights, mean body weight gains, decreased water consumption, mortality, and renal toxicity.

Reliability : (1) Reliable without restrictions
1d-Test procedure in accordance with generally accepted scientific standards and described in sufficient detail

Flag : Critical study for SIDS endpoint

21.01.2005 : (55)

Type : Sub-chronic
Species : Rat, mice
Sex : male/female
Strain : F334/N(rat), $B_6C_3F_1$(mice)
Route of admin. : Oral (drinking water)
Exposure period : 92 days
Post exposure period : No
Doses : Rats
0, 125, 500, 1,000, 2,000, and 4,000 ppm $BaCl_2{\cdot}2H_2O$ in distilled drinking water (corresponding to the final dose of 0, 4.3, 17.0, 32.9, 61.1, and 120.7 mg Ba/kg bw to males and 0, 5.8, 23.3, 45.4, 80.9, and 136.4 mg Ba/kg bw to females)

Mice
0, 125, 500, 1,000, 2,000, and 4,000 ppm $BaCl_2{\cdot}2H_2O$ in distilled drinking water (corresponding to the average daily dose of 0, 12.4, 41.9, 82.9, 164.7, and 436.2 mg Ba/kg bw to males and 0, 11.5, 48.0, 83.0, 165.8, and 562.0 mg Ba/kg bw to females)

Control group : yes
Year : 1992
GLP : no data
Test substance : Other TS; Barium chloride dihydrate(CAS No. 10326-27-9); J.T. Baker Chemical Company; Lot No. 123120
Test conditions : Age at study initiation: 32 days (rat and mice)
No. Of animals per sex per dose: 10 males and 10 females

Study design
Animals were housed five per cage; available for water and feed. Water consumption was measured twice weekly; clinical findings were recorded twice daily; animals were weighted weekly.
The behavioral test battery were conducted on all rats and mice at 0, 45 to 48, and 91 days of exposure. It consisted of (1) undifferentiated motor activity, (2) forelimb and hindlimb grip strengths, (3) thermal sensitivity to a 55 ºC water bath, (4) startle response to acoustic and air-puff stimuli, and (5) hindlimb foot splay.
All animals were examined for gross lesions and their tissues. Organ weights were recorded for brain, liver, right kidney, lung, thymus, right testis, heart, and adrenals. Complete histologic exams were performed on animals of the 4,000 ppm and control groups. Because histopathologic changes were observed in several tissues (thymus, spleen, kidneys, and lymph nodes) from rats and mice in the 4,000 ppm group, these tissues were examined from lower dose animals to determine a no-effect level.
Blood were collected and the following items were measured; serum sodium, potassium, calcium, and phosphorus.
Results : Rats
Three of 10 male and 1 of 10 female rats in the 4,000 ppm groups died during the last week. Body weights of both sexes in the 4,000 ppm groups were significantly ($p < 0.05$) lower than the controls. Rats in the 4,000 ppm groups consumed 70 % of water consumed by the controls. No clinical signs of toxicity were observed except for signs of weight loss.
The liver weights of rats received 4,000 ppm were depressed. The absolute kidney weights were elevated in the 1,000 and 4,000 ppm females, and the relative kidney weights were were elevated in the 4,000 ppm to males and 1,000 ppm or greated to females. Tymus weights were depressed in the high dose female rats.
In the male rats, there was a significant elevation in phosphorus in the 1,000, 2,000, and 4,000 ppm groups compared with the controls. In the female rats, a significant elevation in phosphorus was seen in the 500, 1,000, 2,000, and 4,000 ppm groups.
Treatment-related lesions associated with the barium chloride toxicity were present in the kidneys of rats received 4,000 ppm. There were no treatment-related histopathologic effects in the brain or other tissues. Rats exposed to 2,000 ppm or lower did not show any consistent changes in behavioral indices (motor activity, fore- and hindlimb grip strength, and thermal sensitivity). No significant or dose-related effects were seen in the startle response to acoustic and air-puff stimuli or the hindlimb foot splay.

Mice
Six of 10 male and 7 of 10 female mice in the 4,000 ppm groups died within the 13th day of the study. Body weights of both sexes in the 4,000 ppm groups were significantly ($p < 0.05$) lower than the controls. Mice in the 4,000 ppm groups consumed 85 % of water consumed by the controls. No clinical signs of toxicity were observed except for signs of weight loss.
The liver weights of mice received 2,000 ppm or greater were depressed. The absolute kidney weights were elevated in the high dose mice, and the relative kidney weights were elevated in the 4,000 ppm mice. Thymus weights were depressed in the high dose mice.
The serum electrolyte analyses were not performed in mice.

		Histopathologic findings were similar to those of rats, but more severe renal toxicity were observed that rats. Mice exposed to 2,000 ppm or lower did not show any consistent changes in behavioral indices (motor activity, fore- and hindlimb grip strength, and thermal sensitivity). No significant or dose-related effects were seen in the startle response to acoustic and air-puff stimuli or the hindlimb foot splay.
Conclusions	:	The no-effect level for barium toxicity in this study based on depressed body weight gains and chemically related lesions in the kidney and lymphoid tissue was 2,000 ppm barium chloride dihydrate in the drinking water. (corresponding to the final barium dose of 61.1 and 80.9 mg Ba/kg bw/day to male and female rats, respectively, and 164.7 and 165.8 mg Ba/kg bw/day to male and female mice, respectively)
Reliability	:	(1) Reliable without restrictions 1d – Test procedure in accordance with generally accepted scientific standard and described in sufficient detail
Flag	:	Critical study for SIDS endpoint
07.04.2005	:	(16)

Type	:	Sub-chronic
Species	:	other: chick
Sex	:	male/female
Strain	:	no data
Route of admin.	:	oral feed
Exposure period	:	4 weeks
Frequency of treatm.	:	Dose provided in feed
Post exposure period	:	No
Doses	:	Barium was included in the diet at levels ranging from 0 – 1,280 ppm or 0 – 32,000 ppm in two separate experiments.
Control group	:	yes, concurrent no treatment
NOAEL	:	1,000 ppm
LOAEL	:	2,000 ppm
Method	:	
Year	:	1960
GLP	:	no data
Test substance	:	Other TS; Barium hydroxide and barium acetate
Test conditions	:	Study divided into two section; single dose toxicity (summarized in Section 5.1.1) and effect on growth (summarized here). EFFECT ON GROWTH. *Experiment 1*. 12 lots of chicks (10 male and 10 female per lot) were given basal diet for the first week. When chicks were a week old they were randomly assigned to an experimental diet group. Barium (hydroxide) levels used: 0, 1.25, 2.5, 5, 10, 20, 40, 80, 160, 320, 640, and 1,280 ppm. *Experiment 2*. 16 lots of chicks (20 females per lot) received experimental diet from one day of age. Barium was added as barium hydroxide (barium levels: - 0, 500, 1,000, 2,000, 4,000, 8,000, 16,000, and 32,000 ppm) or as barium acetate (barium levels: - 0, 250, 500, 1,000, 2,000, 4,000, 8,000, and 16,000 ppm). Both experiment 1 and 2 were terminated when the chicks were 4 weeks old.
Results	:	*Experiment 1*. There was no apparent effect on body weight gain between weeks 1 to 4. Only one chick in the 5 ppm group died. *Experiment 2*. 2,000 ppm and higher doses of barium (hydroxide or acetate) depressed body weight gain. At 8,000 ppm barium (hydroxide or acetate) caused more than half the chicks in the group to die before week 4. At 16,000 ppm (hydroxide or acetate) all chicks died within 7 days. At

		32,000 ppm all chicks died within 5 days. The gain in chicken weight in the two groups (hydroxide or acetate) was similar, indicating similar toxicity of the two compounds on growth. The data indicate that 1,000 ppm barium (hydroxide or acetate) was well tolerated, but toxicity became apparent at 2,000 ppm.
Reliability	:	(2) Reliable with restrictions 2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (37)

Type	:	Sub- acute
Species	:	rat
Sex	:	No data
Strain	:	Albino
Route of admin.	:	inhalation
Exposure period	:	One month
Frequency of treatm.	:	no data
Post exposure period	:	
Doses	:	33.4 ± 3.6 mg/m^3
Control group	:	Yes
Test substance	:	Other TS; Barium carbonate
Test conditions		This data is presented in a publication which includes studies on rabbits, rats and mice administered barium carbonate by the enteral, parenteral, inhalation and intratracheal routes. There is no data on strain of species, number per group, duration or frequency of dosing or method of exposure. The control groups were kept under the same conditions in the animals house. Albino rats were exposed to barium carbonate dust at a concentration of 33.4 ± 3.6 mg/m^3 in a chamber
Results	:	There were changes noted in red and white blood cells, inhibition of enzyme activity, effects on the metabolism and vascular tone, reduced hepatic activity. The report did not define any of the changes. Pathomorphological examination revealed a picture of desquamative bronchitis in the bronchi and focal thickening of the interalveolar septa in lung tissue. There were signs of granular dystrophy in the heart, liver, and kidney.
Reliability	:	(4) Not assignable 4b-Secondary literature

21.01.2005 (72)

Type	:	Chronic
Species	:	rat
Sex	:	male
Strain	:	Albino
Route of admin.	:	inhalation
Exposure period	:	4 months.
Frequency of treatm.	:	6 times a week, 4 hours per day.
Post exposure period	:	Yes, period not defined.
Doses	:	5.2 ± 0.25 and 1.15 ± 0.15 mg/m^3
Control group	:	yes, concurrent no treatment
Method	:	
Year	:	1977
GLP	:	no data
Test substance	:	Barium carbonate
Results	:	This data is presented in a publication which includes studies on rabbits, rats and mice administered barium carbonate by the enteral, parenteral,

inhalation, and intratracheal routes.

There was no data on species, strain or numbers per group. A control group was included, and exposed to pure air.

Following 4 month inhalation exposure (5.20 ± 0.25 mg/m^3), data indicated that there was a general toxic effect. The following parameters were determined:

Parameter	Experimental	Control
Weight (g)	231 ± 7.4	292 ± 8.5
Arterial press. (mm)	121 ± 3.0	92 ± 2.0
Haemoglobin (%)	75.0 ± 0.9	84.4 ± 0.8
Leukocytes (1000)	18.9 ± 0.8	13.5 ± 0.7
Thrombocytes (1000)	244.3 ± 2.1	259 ± 3.2
Sugar (mg %)	110.0 ± 7.0	180 ± 7.7
Phosphorous (mg %)	130.0 ± 2.5	120.4 ± 3.5
total protein (g %)	7.2 ± 0.1	9.0 ± 0.2
Alkaline phosphatase (mg of inorganic Phosphorous)	26.3 ± 1.0	17.0 ± 3.0
Cholinesterase (U of ext. x 100)	22.1 ± 0.6	32.6 ± 0.5
Urinary calcium (% mg)	5.7 ± 0.12	3.3 ± 0.15.

A bromosulftalein test of liver function was performed at the end of the study. The data indicated impaired detoxifying liver function; in control animals the dye was absent 10 minutes after administration, while in animals exposed to barium carbonate, 17.4 % of the dye was still present 10 minutes after administration. At the conclusion of the experiment, electrocardiogram (ECG) assessment showed barium carbonate per se did not have any effect on cardiac function. Proserine use demonstrated increased cholinergic effects on the heart.

The changes observed in the experimental group exposed to barium carbonate did not disappear after the recovery period (recovery time unspecified).

Pathomorphological changes observed in the heart, liver, and kidneys were mild and characterized by granular dystrophy. However, in the lungs there were signs of moderate perivascular and peribronchial sclerosis with focal thickening of the interalveolar septa and collagenation.

On the whole the pathological changes observed in the lungs support the view that prolonged inhalation exposure to barium carbonate has toxic effects.

Virtually no changes were observed in animals exposed to barium carbonate dust at 1 mg/m^3.

Reliability : (4) Not assignable
4b-Seondary literature

21.01.2005 (72)

Type :
Species : rat
Sex : male/female
Strain : Sprague-Dawley
Route of admin. : other: gavage
Exposure period : 10 days

Frequency of treatm. : Once daily
Post exposure period :
Doses : 0 mg/kg(deionized water vehicle), 100 mg/kg, 145 mg/kg, 209 mg/kg, and 300 mg/kg
Control group : yes, concurrent vehicle
Method :
Year : 1988
GLP : no data
Test substance : Other TS; Barium cChloride; 99+ % purity, Aldrich Chemical Company, Lot No. 20245L
Statistical methods : All data were subjected to an analysis of variance and test for homogeneity and a Dunnett's t-test. Nonhomogeneous data were subjected to Wilcoxon Rank Sum Test. Those values that differed from the vehicle group at $p < 0.05$ were considered insignificant.
Test conditions : This study is divided into a 1-day (summarized in Section 5.1.1) and 10-day study (summarized here).

TEN DAY STUDY

Male and female rats were randomized into groups consisting of 10 males and 10 females per group.

Barium chloride was dissolved in deionized water to give 1.5 % solution. The solution was prepared daily and doses were delivered at a volume of 6.7, 9.7, 13.9, and 20.0 mL/kg. Vehicle control was given at 20 mL/kg.

After dosing animals were observed twice daily with at least 5 hours between observations. Bodyweights were determined at days 1, 5, and 11 (termination). At termination, animals were subject to necropsy. Gross pathological examination was performed, followed by removal and weighing of selected organs (brain, liver, spleen, lungs, thymus, kidneys and testes or ovaries). Histopathological evaluation was performed on liver, kidney, and heart tissue. Urinalysis and various hematologoical and clinical chemistry parameters were determined.
Results : Body weight changes and mortality.
The mean body weight of all groups increased between day 1 and at study termination. Body weights were not affected in all rats. The only deaths observed were 1 male rat in the 209 mg/kg dose group and 3 females receiving 300 mg/kg. There were no consistently observed pathological findings at necropsy.

Organ weights.
For male rats, none of the values were significantly different from vehicle control. Female rats showed significant decreases ($p \leq 0.05$; values are mean ± standard error of mean) in:
i) liver/brain weight ratio at 145 mg/kg (5.6 ± 0.11) compared to vehicle control (6.39 ± 0.29)
ii) kidney/brain weight ratio at 100 (1.03 ± 0.03), 145 (1.01 ± 0.02), and 209 (1.03 ± 0.04) mg/kg compared to vehicle control (1.18 ± 0.03). There was no significant decrease at 300 mg/kg (1.07 ± 0.03), and
iii) ovary weight at 300 mg/kg (0.11 ± 0.01 g) compared to vehicle control (0.14 ± 0.01 g) and ovaries/brain weight ratio (0.06 ± 0.00), compared to vehicle control (0.08 ± 0.01).

The decreases in liver/brain and kidney/brain weight ratios are probably not compound related since they are not evident at the highest dose. The reduced ovaries/brain weight ratio is more likely to be barium induced since the effect is seen at 30 mg/kg in a 1 day study.

Clinical chemistry.
Serum chemistry included SGPT (ALT), SGOT (AST), ALP, BUN (blood urea nitrogen), protein, glucose, cholesterol, bilirubin, creatinine, calcium phosphate, albumin and chloride. The only significant differences ($p \leq 0.05$) were decreases in BUN at 300 mg/kg in male rats (17 ± 1 mg/Dl) compared to vehicle control (21 ± 1 mg/Dl) and at all four doses in female rats (18 ± 1 mg/Dl for all four dose levels) compared to vehicle control (21 ± 1 mg/Dl). The reduced BUN levels are an indication of a barium-related effect since it occurs at all female dose levels and the highest male dose.

Hematology.
The only significant difference was a decrease in leukocytes in males at 209 mg/kg, which was not barium induced, as it was not observed at higher dose. Coagulation data and differential cell counts revealed no significant differences.

Histopathology.
Examination of the liver, kidney, and heart tissue revealed no lesions or changes that were considered to be related to barium chloride administration. Various tissue changes were seen in treated and control groups, but they were of the type encountered in laboratory rats and were considered not to be related to the test conditions.

There is no data reported for urinalysis.

The administration of barium chloride in this study produced compound related effects on ovaries and BUN. It is concluded that short-term oral exposure to barium chloride at doses up to 209 mg/kg produces no significant adverse health effects.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (10)

5.5 GENETIC TOXICITY 'IN VITRO'

Type : Bacterial reverse mutation assay
Species/Strain : *Salmonella tryphimurium* TA97, TA98, TA100, TA1535, and TA1537
Method : Other
Doses : 100, 333, 1,000, 3,333, 10,000 µg/plate
Metabolic activation : S9 mix from Aroclor1254-induced male Sprague-Dawley rat or Syrian hamster liver. 10 % and 30 %
Statistical Methods : Mean ± standard error from three plates
Year : 1994
GLP : no data
Test substance : Other TS: Barium chloride dihydrate(99 % pure)
Remarks : Testing was performed as reported by Zeiger *et al.* (1992).
Barium chloride dihydrate was incubated with the *Salmonella typhimurium* strains either in buffer or S9 mix for 20 minutes at 37 ^{O}C. Top agar supplemented with *l*-histidine and *d*-biotin was added, and the contents of the tubes were mixed and poured onto the minimal glucose agar plates. Histidine-independent mutant colonies were counted after incubation for 2 days at 37 ^{O}C.
Each trial consisted of positive and negative controls and at least 5 doses of barium chloride dihydrate.
For four strains(TA100, TA1535, TA97, TA98), six trials; two for –S9, +10 % hamster S9, +30 % hamster S9, +10 % rat S9 and +30 % rat S9 were performed and three trials; -S9, +30 % hamster S9 and +30 % rat S9 for

	the strain TA1537.
Results	: Barium chloride dihydrate did not induce gene mutations in any of five strains of *S. Typhimurium* when tested ina preincubation protocol with and without S9.
Reliability	: (1) Reliable without restrictions 1d – Test procedure in accordance with generally accepted scientific standard and described in sufficient detail
Flag	: Critical study for SIDS endpoint
21.01.2005	: (55)

Type	: *In vitro* mutagenicity test
Species/Strain	: L5178Y mouse lymphoma cells
Method	: Other
Doses	: 62.5, 125, 250, 500, 750, 1,000 μg/mL
Metabolic activation	: S9 mix from Aroclor1254-induced male Fisher 344 rat liver
Statistical Methods	:
Year	: 1994
GLP	: no data
Test substance	: Other TS: Barium chloride dihydrate(99 % pure)
Remarks	: The experimental protocol is presented in detail by Myhr *et al.* (1985). 6 x 10^6 cells were incubated with barium chloride dihydrate for four hours in the absence and the presence of metabolic activation system. The treatment medium was replaced with fresh medium and the incubation was continued for additional 48 hours to express the mutant phenotype. 3 x 10^6 cells were plated in trifluorotymidine(TFT) containing medium for selection of TFT-resistant(TK $^{-/-}$) cells and 600 cells were plated in nonselective medium for cloning eficiency determination.
Results	: Barium chloride dihydrate, at concentrations of 250 μg/mL and above induced gene mutaions at the TK $^{+/-}$ locus of L5178Y mouse lymphoma cells in the presence of Aroclor1254-induced male Fisher 344 rat liver S9. Without S9, no increase in the number of mutant colonies was observed. At 1,000 μg/mL, a precipitate was observed and was not considered for making the positive call.
Reliability	: (1) Reliable without restrictions 1d – Test procedure in accordance with generally accepted scientific standard and described in sufficient detail
Flag	: Critical study for SIDS endpoint
21.01.2005	(55)

Type	: *In vitro* test for sister chromatid exchange and chromosome aberration
Species/Strain	: Chinese hamster ovary(CHO) cells
Method	: Other
Doses	: 50 – 3,000 μg/mL, at least four doses per trial
Metabolic activation	: S9 mix from Aroclor1254-induced male Sprague-Dawley rat liver
Statistical Methods	: The slope of the dose response curve and the indivisual dose points were analysed.
Year	: 1994
GLP	: no data
Test substance	: Other TS: Barium chloride dihydrate(99 % pure)
Remarks	: Testing was performed as reported by Galloway *et al.* (1987). *Sister Chromatid Exchange Test:* Without S9, CHO cells were incubated for 26 hours with barium chloride dihydrate and bromodeoxyuridine (BrdU) was added after 2 hours of initiation. The medium was changed with fresh medium containing BrdU and Colcemid and incubated for 3 hours. Cells were harvested and stained. With S9, cells were incubated with barium chloride dihydrate in serum free medium plus S9 for 2 hours. The medium was changed with fresh medium containing serum and BrdU and incubation continued for 26 to 27 hours, with Colcemid present for the final two hours.

Fifty second-division metaphase cells were scored for frequency of SCEs/cell from each dose level.

Chromosomal Aberrations Test:
Cells were incubated with barium chloride dihydrate for 10 hours and another 2 hours after Colcemid was added. The cells were harvested and stained for karyotype scoring. One hundred first division metaphase cells were secored at each dose level.

Results : Barium chloride dihydrate did not induce sister chromatid exchange or chromosome aberations with or withour S9 mix. Cell cycle was normal for both tests. At doses of 2,000 µg/mL and above, precipitaion was noted in the chromosome aberation assay.

Reliability : (1) Reliable without restrictions
1d – Test procedure in accordance with generally accepted scientific standard and described in sufficient detail

Flag : Critical study for SIDS endpoint

21.01.2005 (55)

5.6 GENETIC TOXICITY 'IN VIVO'

5.7 CARCINOGENICITY

Type : Chronic
Species : Rat, mice
Sex : male/female
Strain : F334/N(rat), B6C3F_1(mice)
Route of admin. : Oral (drinking water)
Exposure period : 103 weeks(male mice), 104 weeks(male rats and female mice), 105 weeks(female rats)
Post exposure period : No
Doses : Rats
0, 500, 1,250, and 2,500 ppm $BaCl_2 \cdot 2H_2O$ in the drinking water (corresponding to the average daily dose of 0, 15, 30, and 60 mg Ba/kg bw to males and 0, 15, 45, and 75 mg Ba/kg bw to females)

Mice
0 , 500, 1,250, and 2,500 ppm $BaCl_2 \cdot 2H_2O$ in the drinking water
(corresponding to the average daily dose of 0, 30, 75, and 160 mg Ba/kg bw to males and 0, 40, 90, and 200 mg Ba/kg bw to females)

Control group : Yes, concurrent vehicle
Year : 1987
GLP : no data
Test substance : Barium chloride dihydrate(CAS No. 10326-27-9); J.T. Baker Chemical Company; Lot No. 423103
Statistical methods : *Analysis of neoplasm incidences:* The primary statistical analysis used was a logistic regression analysis in which neoplasm prevalence was modeled as a logistic function of chemical exposure and time. Other methods used were the following; the life table test, appropriate for rapidly lethal neoplasms, and the Fisher exact test and the Cochran-Armitage trend test, procedures based on the overall proportion of neoplasm-bearing animals.

Analysis of nonneoplastic lesion incidences: The primary statistical analysis used was a logistic regression analysis in which lesion prevalence was modeled as a logistic function of chemical exposure and time.

Test conditions : *Age at study initiation*: rats-6 weeks, mice-7weeks
No. Of animals per sex per dose: 60 males and 60 females

Study design
Rats and mice were housed five and one per cage, respectively; available for water and feed. Water consumption was measured weekly; clinical findings and body weights were recorded initially, weekly for 13 weeks, then monthly and at the interim evaluation.
Necropsy was performed on all animals. Organ weights recorded for adrenal gland, brain, heart, right kidney, liver, lung, ovary, right testis, spleen, thymus, and ulterus. Blood were collected at the 15-month interim evaluations and the following items were measured; hematocrit, hemoglobin, erythrocytes, mean erythrocyte volume, mean erythrocyte hemoglobin, mean erythrocyte hemoglobin concentration, platelets, reticulocytes, nucleated erythrocytes, leukocyte count and differential, urea nitrogen, creatinine, calcium, phosphorus, alanine aminotransferase, creatine kinase, lactate dehydrogenase, sorbitol dehydrogenase(rats), and γ-glutamyltransferase. Plasma barium levels were determined in rats and mice; bone density, barium, calcium, and phosphorus levels in bone were determined in control and high-dose rats. Histopathology was performed on all animals. In addition to gross lesions, tissue masses, and associated lymph nodes, the tissues examined included; adrenal gland, brain, bone marrow, clitoral gland(rats), large intestine(cecum, colon, rectum), epididymis, esophagus, gallbladder(mice), heart, kidney, liver, lung, mandibular and mesenteric lymph nodes, mammary gland, nose, ovary, pancreas, parathyroid gland, pituitary gland, preputial gland(rats), prostate gland, salivary gland, seminal vesicle, skin, small intestine(duodenum, jejunum, ileum), spleen, stomach(forestomach and glandular), testis, thymus, thyroid gland, trachea, urinary bladder, and uterus.

Results : Rats
Survival: Survival of exposed male and female rats was similar to that of the controls.
Clinical signs: No chemical-related clinical findings were observed.
Body weights: The final mean body weight of males receiving 2,500 ppm and females receiving 1,250 and 2,500 ppm was lower than that of the controls(5 %, 6 %, and 11 %).
Water consumption: Beginning as early as week 5, water consumption by rats receiving 2,500 ppm was substantially depressed (males: 11 % to 30 %; females: 19 % to 33 %).
Clinical chemistry and haematology: these parameters were considered to be within the range of normal values.
Plasma barium levels: There was significant increase in males receiving 2,500 ppm and all exposed groups of female.
Bone analysis: Barium levels in bone were 400 times greater in males and females from 2,500 ppm than in controls.
Pathology findings: At the end of 2 years, there was no increased incidences of neoplasms or nonneoplastic lesions that could be related to test substance. However, there was dose-related decreased incidences of adrenal medulla pheochromocytomas and mononuclear cell leukemia in male rats.

Mice
Survival: Survival of male and female rats receiving 2,500 ppm was significantly lower than that of the controls.
Clinical signs: No chemical-related clinical findings were observed.
Body weights: Final mean body weights of male and female mice receiving 2,500 ppm were lower than those of controls.
Water consumption: Water consumption by exposed mice was similar to that by the controls.
Clinical chemistry and Haematology: There was no significant difference

		between exposed and control groups. *Plasma barium levels:* Dose-related increases were observed in exposed male and female mice. *Pathology findings:* No increase incidences of neoplasms were observed in exposed mice. The incidence of nephropathy was significantly increased in male and female mice receiving 2,500 ppm. In 2,500 ppm male and female group the relative and absolute spleen weights were lower than the controls and incidences of lymphoid depletion were increased.
Conclusions	:	There was no evidence of carcinogenic activity(showing no chemical-related increase of malignant or benign neoplasms) of barium chloride dihydrate in both sexes of rats and mice that received 500, 1,250, and 2,500 ppm.
Reliability	:	(1) Reliable with restrictions 1d – Test procedure in accordance with generally accepted scientific standard and described in sufficient detail
Flag	:	Critical study for SIDS endpoint
21.01.2005		(55)

5.8.1 TOXICITY TO FERTILITY

Type	:	Sub-chronic
Species	:	Rats, mice
Sex	:	Male/female
Strain	:	F334/N(rat), $B_6C_3F_1$(mice)
Route of admin.	:	Oral (drinking water)
Exposure period	:	
Premating exposure period for males	:	60 days in both species
Premating exposure period for females	:	30 days in both species
Post exposure period	:	No
Doses	:	Rats 0, 1,000, 2,000, and 4,000 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the calculated average dose of 0, 63.5, 112, and 201.5 mg Ba/kg bw/day to males and 0, 64.5, 114, and 179.5 mg Ba/kg bw/day to females) Mice 0, 500, 1,000, and 2,000 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the calculated average dose of 0, 52.9, 102.5, and 206 mg Ba/kg bw/day to males and 0, 58.9, 105.2, and 199.8 mg Ba/kg bw/day to females)
Control group	:	yes
Year	:	1992
GLP	:	No data
Test substance	:	Other TS; Barium chloride dihydrate(CAS No. 10326-27-9); J.T. Baker Chemical Company; Lot No. 123120
Test conditions	:	Age at study initiation: 32 days (rats and mice) No. Of animals per sex per dose: 20 males and 20 females *Study design* The males were placed in individual cages and one female receving the same dose level was cohabited with each male with each male for up to 1 week. Each morning following a day of cohabition, each female was examined for the presence of a vaginal plug (mice) or microscopic evidence of sperm in a vaginal swab (rats). When evidence of mating was found, the female was separated from the male; after mating determinations were made on the eighth day of cohabition, all remaining

pairs were separated. Femals were weighed when evidence of mating was found and on the day of parturition. All femals were terminated on days 96 and 97; the vagina, cervix, oviducts, and ovaries were grossly examined and the implantation sites in the uteri were counted.
An evaluation of sperm morphology, density, and motility, male reproductive organ weights, and vaginal cytology among treated and control groups were performed.

Results : The results of the controls and the high dose groups were available.
Rats
Although the pregnancy rates (from 40 % in the controls and 65 % in the 4,000 ppm group) were below the generally accepted norms, this problem was not corrected by remating due to restriction in the study dosing schedule/design. The average gestation period of surviving dams was 22 to 22.5 days. The number of implants per preganat dam was 9.6±1.10 and 7.7±0.52 in the controls and 4,000 ppm group, respectively.

Mice
The pregnancy rates were 55 % in the controls and ranged from 55 to 70 % in the treated groups. The average length of gestation of the control and test mice ranged from 18.5 to 18.9 days. There was no evidence of maternal weight gain during pregnancy compared compared with the controls.

There were no treatment-related effects of barium chloride dihydrate on epididymal sperm count, sperm motility, sperm morphology, testis or epididymal weight, or vaginal cytology in either species.

Conclusions : The NOAEL on reroductive toxicity was 4,000 ppm for rats and 2,000 ppm for mice.

Reliability : (2) Reliable with restrictions
2e-Study well documented, meets generally accepted scientific principles, acceptable for assessment

Flag : Critical study for SIDS endpoint

07.04.2005 : (16)

Type : Chronic
Species : Rat, mice
Sex : male/female
Strain : F334/N (rat), B6C3F1 (mice)
Route of admin. : Oral (drinking water)
Exposure period : 103 weeks (male mice), 104 weeks (male rats and female mice), 105 weeks (female rats)
Post exposure period : No
Doses : Rats
0, 500, 1,250, and 2,500 ppm $BaCl_2 \cdot 2H_2O$ in the drinking water (corresponding to the average daily dose of 0, 15, 30, and 60 mg Ba/kg bw to males and 0, 15, 45, and 75 mg Ba/kg bw to females)

Mice
0 , 500, 1,250, and 2,500 ppm $BaCl_2 \cdot 2H_2O$ in the drinking water (corresponding to the average daily dose of 0, 30, 75, and 160 mg Ba/kg bw to males and 0, 40, 90, and 200 mg Ba/kg bw to females)

Control group : Yes, concurrent vehicle
Year : 1987
GLP : No data
Test substance : Barium chloride dihydrate (CAS No. 10326-27-9); J.T. Baker Chemical Company; Lot No. 423103
Test conditions : See above section 5.7 Carcinogenicity
Results : The results were summarized in the following tables.

Table. Pathology findings of the genital system in male rats and mice

Organs	Speicies	Rats				Mice			
	Concentration (ppm)	0	500	1,250	2,500	0	500	1,250	2,500
Preputial gland	No. of examined	10	10	10	10	32	33	26	30
	Remarkable								
	- Cyst				1	20	17	20	23
	- Inflammation, acute, focal		2	1	1				
	- Inflammation, chronic, focal	1	2	1	1	1			
	- Abscess					1			
	- Ectasia					21	21	10	14
Prostate	No. of examined	10	10	10	10	50	47	48	49
	Remarkable								
	- Hyperplasia				1				
	- Cyst								1
	- Dilatation						1		
	- Inflammation, chronic					2			
	- Inflammation, granulomatous							1	
	- Artery, Inflammation, chronic					1			
Seminal vesicle	No. of examined	10	10	10	10	50	50	49	50
	Remarkable								
	- Fibrosis				1				1
	- Hemorrhage		1						
	- Atrophy							1	
	- Dilatation					11	10	10	2
	- Inflammation, granulomatous							1	
Testes	No. of examined	10	10	10	10	51	50	49	50
	Remarkable								
	- Bilateral, interstitial cell, hyperplasia	2	2	3	3				
	- Bilateral, seminiferous tubule, atrophy, focal		1						
	- Interstitial cell, hyperplasia	1	2		2			2	
Epididymis	No. of examined	-	-	-	-	51	49	49	50
	Remarkable								
	- Inflammation, chronic							1	
	- Inflammation, granulomatous						1	1	1
Penis	No. of examined	-	-	-	-	-	-	-	1
	Remarkable								
	- Inflammation, acute								1

Table. Pathology findings of the genital system in female rats and mice

Organs	Speicies	Rats				Mice			
	Concentration (ppm)	0	500	1,250	2,500	0	500	1,250	2,500
Clitoral gland	No. of examined	50	49	50	47	1			2
	Remarkable								
	- Abscess		7	3					
	- Cyts	12	4	2	5				1
	- Inflammation, acute		1	1	2				
	- Inflammation, chronic			1	1				

Ovary	No. of examined	49	50	50	50	49	52	49	53
	Remarkable								
	- Congestion		3	1	1	1			1
	- Cyst	2	3	2	4	17	9	12	10
	- Granuloma				1				
	- Angiectasis							1	
	- Atrophy								1
	- Hemorrhage					1			3
	- Thrombosis							1	
	- Follicle, hemorrhage						2	1	
Uterus	No. of examined	50	50	50	50	50	53	50	54
	Remarkable								
	- Abscess				1				
	- Congestion	1							
	- Cyts	2		1	1		1		
	- Dilatation	2			1	14	14	13	6
	- Hemorrhage		1			2		1	1
	- Prolapse				1				
	- Thrombosis	1				1	1		
	- Endometrium, cyst		1	1	3				2
	- Endometrium, necrosis				1				
	- Endometrium, hyperplasia, cystic					40	36	34	20
	- Endometrium, metaplasia,							1	
	squamous					3	2	3	
	- Angiectasis						4	4	20
	- Atrophy					1			
	- Mineralization					1			
	- Necrosis						1		
	- Lumen, hemorrhage					1			
	- Myometrium, inflammation, chronic,								
	focal								
Vagina	No. of examined	2	-	-	-	-	-	-	-
	Remarkable								
	- Inflammation, acute	1							

Conclusions : there was no increased incidences of nonneoplastic lesions of genital system that could be related to test substance.
Reliability : (1) Reliable with restrictions
1d – Test procedure in accordance with generally accepted scientific standard and described in sufficient detail
Flag : Critical study for SIDS endpoint
21.01.2005 (55)

Type : other
Species : Rat
Sex : female
Strain : other: no data
Route of admin. : inhalation
Exposure period : 4 months
Frequency of treatm. :
Premating exposure period:
Male :
Female :
Duration of test :
No. Of generation studies :
Doses : 13.4 ± 0.7 and 3.1 ± 0.16 mg/m^3
Control group :
Method :
Year : 1977

GLP	:	no data
Test substance	:	Other TS; Barium carbonate
Test conditions	:	This data is presented in a publication which includes studies on rabbits, rats, and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes. Female rats were exposed to barium carbonate dust (13.4 ± 0.7 and 3.1 ± 0.16 mg/m^3) for 4 months. Although not specified, in another 4-month study, exposure was for 6 days a week, 4 hours a day. It is assumed this regime was used in this study.
Results	:	At the higher exposure concentration there was a shortening of the mean duration of the estrous cycle. There were changes noted in the morphological structure of the ovaries in which the proportion of mature and dying follicles was altered. These are thought to be a result of the intensification of the process of follicle atresia and underdevelopment.
Reliability	:	(4) Not assignable 4b-Secondary literature
Flag	:	Critical study for SIDS endpoint

21.01.2005 (72)

5.8.2 DEVELOPMENTAL TOXICITY/TERATOGENICITY

Type	:	Sub-chronic
Species	:	Rat, mice
Sex	:	male/female
Strain	:	F334/N(rat), $B_6C_3F_1$(mice)
Route of admin.	:	Oral (drinking water)
Exposure period	:	
Premating exposure period for males	:	60 days in both species
Premating exposure period for females	:	30 days in both species
Post exposure period	:	No
Doses	:	Rats 0, 1,000, 2,000, and 4,000 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the calculated average dose of 0, 63.5, 112, and 201.5 mg Ba/kg bw/day to males and 0, 64.5, 114, and 179.5 mg Ba/kg bw/day to females) Mice 0, 500, 1,000, and 2,000 ppm $BaCl_2 \cdot 2H_2O$ in distilled drinking water (corresponding to the calculated average dose of 0, 52.9, 102.5, and 206 mg Ba/kg bw/day to males and 0, 58.9, 105.2, and 199.8 mg Ba/kg bw/day to females)
Control group	:	Yes
Year	:	1992
GLP	:	no data
Test substance	:	Other TS; Barium chloride dihydrate(CAS No. 10326-27-9); J.T. Baker Chemical Company; Lot No. 123120
Test conditions	:	Age at study initiation: 32 days (rats and mice) No. Of animals per sex per dose: 20 males and 20 females *Study design* Live offspring were weighed, counted, and examined on day 0 (day of birth) and day 5. Dead pups were recovered from the nest and examined for external abnormalities.
Results	:	The results of the controls and the high dose groups were available. Rats

Concentration (ppm)	0	4,000
Average live litter size on day 0	9.0±1.37	7.2±0.52
Average live litter size on day 5	9.3±1.16	7.1±0.56
Pup weight on day 0	5.70±0.09	5.20±0.06 *
Pup weight on day 5	10.55±0.26	9.93±0.20

* A statistical significance was observed ($p < 0.01$), and it is a maginal reduction

Pup survival to day 5 was 99 % or greater in all treatment groups.
No external abnormalities were observed.

: Mice
A statistical significance was observed in the average live litter size on day 0 and 5 in the 1,000 ppm dose group, but there is no changes in the 2,000 ppm dose group. The survival from birth to postpartum day 5 ragned from 98 to 100 %.
No external anomalies were noted in any of the offspring, and there were no statistical differences in live pup weights.

Conclusions : The NOAEL on developmental toxicity was 4,000 ppm for rats and 2,000 ppm for mice.
Reliability : (2) Reliable with restrictions
2e-Study well documented, meets generally accepted scientific principles, acceptable for assessment
Flag : Critical study for SIDS endpoint
07.04.2005 : (16)

Type : other
Species : Rat
Sex : female
Strain : other: no data
Route of admin. : inhalation
Exposure period : 4 months
Frequency of treatm. :
Premating exposure period
Male :
Female :
Duration of test :
No. Of generation studies :
Doses : 13.4 ± 0.7 and 3.1 ± 0.16 mg/m^3
Control group :
Method :
Year : 1977
GLP : no data
Test substance : Other TS; Barium carbonate
Test conditions : This data was presented in a publication which includes studies on rabbits, rats, and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes.

Female rats were exposed to barium carbonate dust (13.4 ± 0.7 and 3.1 ± 0.16 mg/m^3) for 4 months. Although not specified, in another 4-month study, exposure was for 6 days a week, 4 hours a day. It is assumed this regime was used in this study.
Results : The females of the higher exposure group gave birth to underdeveloped offsprings which showed higher mortality and slower increase in weight during the first two months compared to control. The ability of barium to penetrate through the placental barrier and into milk caused the certain disturbances; decreased lability of the peripheral nervous systems and blood disorders(erythropenia, leukocytosis, eosinophilia, neutrophilia) in the offsprings.

Reliability : (4) Not assignable
4b-Secondary literature

21.01.2005 (72)

Species : other: not clear, rat or rabbit
Sex : female
Strain : other: no data
Route of admin. : oral
Exposure period : 24 days before conception and during the entire pregnancy
Frequency of treatm. : No data
Duration of test : No data
Doses : 1/16 of LD_{50}
Control group :
Method :
Year : 1977
GLP : no data
Test substance : Other TS; Barium carbonate
Results : This data was presented in a publication which includes studies on rabbits, rats, and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes.

Oral administration of 1/16 of LD_{50} (actual dose not specified, but elsewhere in the publication, LD_{50} stated as 418 mg/kg) of barium carbonate to females for 24 days before conception and during the entire pregnancy caused an increase in offspring mortality for a period of 2 months after birth. There was an increase in blood leukocyte count in the offsprings. Administration of sodium benzoate resulted in increased urinary excretion of hippuric acid, indicating an alteration of hepatic activity.

The data would indicate an embryotropic effect of barium expressed in the embryotoxic effect without teratogenic effect.

Reliability : (4) Not assignable
4b-Secondary literature

21.01.2005 (72)

Type : other
Species : rat
Sex : Male
Strain :
Route of admin. : inhalation
Exposure period :
Frequency of treatm. : No data
Premating exposure period
Male :
Female :
Duration of test : No data
No. Of generation studies :
Doses : male rats exposed to barium carbonate at 5.2 ± 0.25 mg/m^3
Control group : No data
Year : 1977
Test substance : Other TS; Barium carbonate
Results : This data was presented in a publication which includes studies on rabbits, rats, and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes.

Females become pregnant only after 5 – 7 copulations. The viability of the offspring was poor: 51.3 % of the young died within 60 days, compared to

		24.4 % of control offspring. Examination of the organs of the rat offspring did not reveal any disturbances. A three-fold increase in embryonal mortality was observed in females mated with males exposed chronically (4 months, 6 days a week, 4 hours a day) to barium carbonate by inhalation (gonads returned to normal 30 days after ending inhalation exposure).
Reliability	:	(4) Not assignable 4b-Secondary literature

21.01.2005 (72)

5.8.3 TOXICITY TO FERTILITIY, OTHER STUDIES

Type	:	
In vitro/in vivo	:	In vivo
Species	:	rat
Sex	:	male
Strain	:	other: no data
Route of admin.	:	inhalation
Exposure period	:	no data
Frequency of treatm.	:	no data
Duration of test	:	one cycle of spermatogenesis
Doses	:	22.6 ± 0.6 mg/m^3 chamber concentration.
Control group	:	other: no data
Method	:	
Year	:	1977
GLP	:	no data
Test substance	:	Other TS; Barium carbonate
Test conditions	:	This data is presented in a publication which includes studies on rabbits, rats, and mice administered barium carbonate by the enteral, parenteral, inhalation, and intratracheal routes. There is no data on strain of species, number per group or frequency of dosing. It appears there was no control group. Male rats were exposed by inhalation to barium carbonate dust, chamber concentration 22.6 ± 0.6 mg/m^3, during one cycle of spermatogenesis.
Results	:	A decrease was observed in the total number of spermatozoids, in the percentage of mobile forms and the time of their motility; osmotic resistance of the spermatozoids was reduced. There was a significant increase in the number of ducts (assumed seminal ducts, but report does not specify) with desquamated epithelium and a reduced number of ducts with 12th stage of meiosis in the testicles. Similar disturbances of spermatogenesis were seen in male rats that had been exposed to 5.2 ± 0.25 mg/m^3 barium carbonate in a 4 month study (see section 5.4).
Reliability	:	(4) Not assignable 4b-Secondary literature

21.01.2005 (72)

5.9 SPECIFIC INVESTIGATIONS

Endpoint	:	other: the effect of barium ions on ^{45}Ca distribution in brain subcellular fractions
Study descr. In chapter	:	

Reference	:	
Type	:	
Species	:	Mouse
Sex	:	Male
Strain	:	Swiss Webster
Route of admin.	:	Intraperitoneal
No. Of animals	:	
Vehicle	:	doubly distilled water
Exposure period	:	
Frequency of treatm.	:	single dose
Doses	:	0, 2, 6.6, and 20 Ba^{2+} mg/kg
Control group	:	
Observation period	:	
Method	:	
Year	:	1978
GLP	:	no data
Test substance	:	Other TS; Barium chloride ($BaCl_2 \cdot 2H_2O$), reagent grade
Test conditions	:	This publication reports on effects of barium and cadmium. Only data relevant to barium are summarized here. *Effect of barium on electroshock susceptibility*. Barium chloride was dissolved in doubly distilled water and administered ip in a volume of 10 mL/kg (barium doses 0, 2, 6.6, and 20 mg/kg). There were 16 groups and the number of animals in each group ranged from 13 – 24. At 0.5 and 24 hours after dose administration, the effect on electroshock threshold was determined. Two levels of electroshock were used: a high amperage level, to determine protection; and a low amperage level, to determine excitation. Effect of barium on ^{45}Ca distribution. Calcium-45 was used to investigate the effect of barium on brain calcium distribution (the publication says “metabolism” and not distribution. I believe this maybe an error since there are no metabolism data reported). Five µCi of ^{45}Ca (as chloride) were administered iv(intravenously), 8 hours prior to sacrifice. Mice were given barium chloride (20 mg/kg, ip) and sacrificed at 0.5 or 24 hours post administration. Brain homogenates were prepared and radioactivity was determined in subcellular fractions of myelin, synaptosomes, mitochondria, nuclei, and microsomes (a different brain was used for each fraction). *Distribution of ^{131}Ba in the brain.* Three µCi of ^{131}Ba(specific activity 0.049 mCi/mg) was added to a dose of 20 mg/kg cold barium, ip. Animals were sacrificed at either 0.5 hours (n = 6) or 24 hours (n = 5) post-administration and subcellular brain fractions (myelin, synaptosomes, mitochondria, nuclei, and microsomes) were quantified.
Results	:	*Effect of barium on electroshock susceptibility* At 0.5 hours after barium administration (6.6 and 20 mg/kg), electroshock threshold (low amperage) was significantly ($p < 0.05$) lowered compared to control. At 24 hours after barium administration (2, 6.6, and 20 mg/kg), electroshock threshold (high amperage) was significantly ($p < 0.05$) increased compared to control. *Effect of barium on ^{45}Ca distribution*. At 0.5 hour after barium administration, the ^{45}Ca in the synaptosomal and myelin fractions was significantly ($p < 0.05$) increased compared to the saline control. At 24 hours post barium administration, the ^{45}Ca in the synaptosomal fraction was significantly ($p < 0.05$) lower than the saline control. The other subcellular fractions showed no significant differences from the saline control.

Distribution of ^{131}Ba in the brain.

At 0.5 hours after barium administration, the distribution of barium across the brain fractions was relatively uniform; approximately 100 Nm/g protein. At 24 hours after barium administration, the barium content was significantly (two-way ANOVA, $p < 0.01$) higher than at 0.5 hours. The barium content of the mitochondrial fraction was significantly ($p < 0.05$) greater than that in any other 24 hour fraction.

Conclusions : The near homogeneous barium content of mouse brain subcellular fractions at 0.5 hours after barium administration, probably reflects the ease with which barium crosses biological membranes. At 24 hours after barium administration total brain barium content increased, especially in the mitochondrial fraction but the high mitochondrial barium content had no effect on the mitochondrial calcium. The increased excitation observed in the electroshock study at 0.5 hours after barium administration could be due to potassium-like depolarization caused by barium, leading to increased excitability. Twenty-four hours after barium administration, barium accumulation in the brain has been demonstrated and this may mimic calcium to depress neuronal excitability.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (60)

5.10 EXPOSURE EXPERIENCE

Type of experience : Human – Medical Data

Remarks : Seven cases of accidental barium carbonate poisoning in one family are reported. Within an hour of the evening meal all seven members of the family were presented to a hospital. Barium carbonate rodenticide (35.5 % by weight) was accidentally used as “flour” to coat fish.

A 48-year old man (Patient 1) developed nausea, perioral paresthesia, vomiting, diarrhea and crampy abdominal pain within 15 minutes of fish ingestion. A syncopal event followed ten episodes of profuse watery diarrhea and vomiting. The man had significant medical history; unstable angina and a three-vessel coronary artery bypass graft. Cardiopulmonary examination was normal and neurological examination showed depressed deep tendon reflexes and mildly decreased motor strength in the lower extremities. Laboratory data included potassium of 2.5 mEq/L (mmol/L) and phosphorous of 1.5 mg/Dl (0.48 mmol/L). ECG showed normal sinus rhythm with frequent premature ventricular contractions and prominent U waves. 50 minutes later, repeat ECG showed ventricular bigeminy and five-beat run of ventricular tachycardia. Sustained ventricular tachycardia was treated with intravenous (iv) procainamide. Administration of iv potassium was started. Concurrent with ventricular tachycardia, the patient developed profound extremity weakness progressing to respiratory paralysis which required ventilatory support. Potassium levels at this time were 1.8 mEq/L. A total of 320 mEq (mmol) of potassium was administered over the first 7 hours. Rhabdomyolysis and pulmonary edema complicated the patient’s recovery.

Ventricular arrhythmias resolved with the correction of hypokalaemia; hypertension resolved within 14 hours without treatment; recovery of respiratory and skeletal muscle function occurred within 48 h of admission. Barium poisoning was confirmed in Patient 1 with serum barium levels of 37.4 ~~u~~µg/Dl (2.72 umol/L) (normal = 3 – 29 ~~u~~µg/Dl (0.22 to 2.11 umol/L)) obtained at 64 hours after admission.

A 38-year old woman (Patient 2) complained of dizziness and numbness of mouth, nose, lips and extremities within 15 minutes following ingestion of the cooked fish. Twitching and spasms of hand and leg muscles, nausea, vomiting, crampy abdominal pain, watery diarrhea and severe headache followed. During clinical evaluation, she developed flaccid paralysis of the extremities associated with chest pain and shortness of breath. ECG showed normal sinus rhythm, frequent premature ventricular beats, flattened T and U waves. Serum potassium was 2.0 mEq/L (mmol/L). The paralysis, paresthesia, numbness and ECG abnormalities resolved within 2 hours of potassium repletion and gastrointestinal symptoms resolved within 24 hours.

The five other family members (Patients 3 – 7; ages 2 to 19) all developed nausea, vomiting, crampy abdominal pain and diarrhea within minutes following ingestion of the cooked fish. A 19-year old, pregnant at 29 weeks of gestation, was treated in hospital for premature labor and hypokalaemia (potassium was 2.5 mEq/L (mmol/L)). The remaining patients were treated symptomatically for gastroenteritis as outpatients. In three of these outpatients, serum electrolytes (including potassium) were evaluated and found to be normal.

Test substance : Other TS; Barium carbonate.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment
Flag : Critical study for SIDS endpoint
21.01.2005 (36)

Type of experience : Human – Medical Data
Remarks : A 22-year old man attempted to commit suicide by taking barium carbonate dissolved in hydrochloric acid. Shortly after ingestion he developed crampy abdominal pain and generalized muscle weakness. About 12 hours later, respiratory failure ensued requiring mechanical ventilation. At the same time, life-threatening arrhythmias including ventricular fibrillation occurred, and he had to be resuscitated for 45 minutes. Serum potassium was 1.5 mmol/L and following correction of this severe hypokalaemia, cardiac rhythm stabilized. Hemodialysis was undertaken in an attempt to remove circulating barium. Pharmacokinetic analysis suggests that hemodialysis shortened barium serum half-life. The patient made a complete and uneventful recovery.
Test substance : Other TS; Barium carbonate.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment
Flag : Critical study for SIDS endpoint
21.01.2005 (65)

Type of experience : Human – Medical Data
Remarks : A young chrome-plate worker suffered life-threatening hypokalaemic paralysis when barium carbonate powder, used in cleaning chrome tanks, blew back into his face. He inhaled the majority of the powder that blew into his face, but did not swallow much.

The young man continued to work and an hour later developed abdominal pain, nausea and vomiting. Another hour later he noted diaphoresis, excess salivation and heaviness in his extremities. He arrived at hospital six hours after the incident at which time he was unable to move his extremities or neck. Deep tendon reflex was absent but he was fully alert and cranial nerve functions were not affected. His serum potassium was 0.3 mmol/L (1.0 mg/Dl) and a diagnosis of hypokalaemic periodic paralysis was established. Subsequently a barium level of 250 mEq/L (normal < 5 mEq/L) was measured. Intravenous potassium was administered and the patient recovered fully.

Industrial poisoning is rare, as is the inhalation route of exposure.

Test substance : Other TS; Barium carbonate
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment
Flag : Critical study for SIDS endpoint
21.01.2005 (66)

Type : other: smooth muscle excitants and depressants
Remarks : The following is taken from a section on barium salts.

The fatal dose of barium carbonate is 5 g.

Once dissolved barium is rapidly absorbed from the alimentary canal. The barium ion is found in most tissues following absorption. Within a few days it disappears from all tissues except bone, being excreted primarily by the fecal route even after parenteral administration.

Early death following barium ingestion may be due to collapse from intense colic or ventricular fibrillation. Death after a few hours is more usually due to
paralysis of respiratory muscles.

Test substance : Other TS; Barium carbonate
Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data
Flag : Critical study for SIDS endpoint
21.01.2005 (74)

Type of experience : Human – Medical Data
Remarks : A 19-year old boy presented to hospital with what transpired to be accidental poisoning with 15 g of barium carbonate ingested the day prior to admission. Ingestion was followed immediately by profuse vomiting and an hour later by watery diarrhea. Four hours later he was taken to hospital and the stomach washed out with magnesium sulfate solution. The patient presented with tingling in the right upper arm, quickly followed by weakness in all four limbs which progressed to involve trunk muscles. Higher mental functions, cranial nerve, and sensory and cerebellar examinations were normal. Motor system showed a power of 0/5 globally and no deep tendon reflex could be elicited. Surprisingly, with the areflexic paralysis, there was increased tone in the lower limbs. ECG was performed. Routine blood investigation at time of admission, including serum electrolytes, was normal. Repeat blood analysis 8 hours after admission showed normal blood count, blood gas analysis and renal and liver function tests. Serum potassium was 2.8 mmol/L and sodium was 140 mmol/L. A diagnosis of barium carbonate induced hypokalaemic paralysis was made, and the patient started on intravenous potassium.

On day 2 the patient had completely recovered. Nerve conduction velocity studies and electromyography (EMG) were performed on day 1 and were sequentially repeated. Nerve conduction velocity studies on day 1 showed low amplitude of compound muscle action potential indicating axonal neuropathy, but similar findings can also be attributed to profound muscle weakness because of neuromuscular junction blockade or myopathy. Loss of F waves and H reflexes on day 1 were explained by the lower amplitudes of compound action potentials on distal nerve stimulation. Loss of F waves and H reflexes with normal distal nerve conduction velocity suggests proximal demyelination or dysfunction at the spinal cord level.

This publication is the first to report on loss of H reflexes and the F response in patients with hypokalaemic periodic paralysis. The study found that barium carbonate induced weakness involved more than neuromuscular junctions activity; it also involved muscles, segments of the reflex arc and probably gamma efferents as the tone was increased.

Test substance : Other TS; Barium carbonate

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (38)

Type of experience : Human – Medical Data

Remarks : Nine patients of barium carbonate poisoning included in the publication satisfied the following criteria:

A.Sudden onset, areflexic, pure motor weakness involving all limbs and without alteration in the level of consciousness or sphincteric function.

B. A demonstrable reduction in serum potassium level during the attack of flaccid paralysis.

In all cases a diagnosis of barium carbonate poisoning was made after a clinical and laboratory evaluation. The laboratory data included complete haemogram, blood urea, sugar, serum creatinine, serum electrolytes, serum calcium and phosphorous, serum T3, T4, electromyography (EMG) and nerve conduction velocity (NCV) studies. Urinary potassium, arterial blood gas, liver function tests and muscle enzymes were also done. Progression of motor weakness, alteration in serum electrolytes and disturbances in cardiac rhythm were closely monitored.

Treatment included gastric lavage with 2 – 5 % magnesium sulfate. Intravenous (iv) magnesium sulfate (2.5 g) was also given. Acute attack of hypokalemic paralysis required iv potassium chloride (not more than 200 mEq of potassium was given in 24 h; in a glucose-free solution at 40 mEq/L; administered at a rate of 10 mEq/h). Mechanical ventilation required in cases of respiratory paralysis was continued until recovery of spontaneous respiration.

It was not possible to quantify the amount of rodenticide barium carbonate ingested in individual cases. The cases developed hypokalaemic paralysis after a few hours of hospitalization. Gastrointestinal symptoms (epigastric pain, nausea, vomiting, dryness of mouth and altered taste) were noted in all cases. Diarrhea was present in two cases only and one patient developed gastrointestinal bleeding. Besides weakness/paralysis (quadriparesis/quadriplegia), other neurological manifestations were involuntary twitching (two cases) and circumoral paraesthesia (one case).

The duration of paralytic attack ranged from 8 hours to 5 days. All patients developing respiratory and/or bulbar paralysis had severe hypokalaemia (serum potassium usually less than 2 mEq/L). Complete recovery was seen in all cases following appropriate treatment. EMG, performed in four cases within a week of admission, did not reveal any abnormalities.

Test substance : Other TS; Barium carbonate.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (2)

Type of experience : Human – Medical Data

Remarks : The following is in a published letter to the editor.

This letter reports the usual symptoms of barium carbonate poisoning, namely hypokalaemia and flaccid paralysis in all limbs, and also trismus which until now had not been reported.

The 28 year old man developed trismus at about 20 hours after ingestion. There were no involuntary movements or convulsions and neck muscles were not involved. The patient could not talk. Cranial nerve examination revealed only bulbar palsy. Percussion myotonia was absent and there was no facial sensory deficit. Four hours later the trismus disappeared along with recovery of limb weakness.

The letter summarizes that trismus may be a manifestation of localized myotonia due to secondary periodic paralysis (hypokalaemic).

Test substance : Other TS; Barium cCarbonate
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (20)

Type of experience : Human – Medical Data
Remarks : A 24-year old intentionally swallowed rat poison containing barium carbonate. About 6 hours later he had abdominal pain, vomiting and loose motions, complained of numbness in all limbs and was unable to walk. At hospital admission he was found to be normotensive, cyanotic, with increased salivation, increased lacrimation and shallow, rapid breathing. He was fully conscious and had no cranial nerve deficit. He had hypotonia with flaccid paralysis with areflexia. Serum potassium levels were 2.1 mEq/L.

He was treated successfully with gastric lavage, general supportive measures taken and 150 mEq of potassium administered intravenously.

Test substance : Other TS; Barium carbonate.
Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (15)

Type of experience : Human – Medical Data
Remarks : A 39 year old women attempted suicide by ingesting 40 g of barium carbonate (used for glazing pottery). She was admitted to hospital 10 hours after ingestion. Her serum potassium concentration was 1.5 mmol (mEq/L). Characteristic signs of barium poisoning were seen in the patient; weakness and hypokalaemia. Reports suggest that the weakness is due to hypokalaemia and that potassium is the antidote. Following gastric lavage she was also given 60 g sodium sulfate (nasogastric tube) and 2.5 g magnesium sulfate, intravenously. Intravenous potassium was administered; 254 mmol in the first three days. Serial plasma concentrations of barium and potassium were determined for a period up to 120 hours after ingestion of barium carbonate and compared to muscle weakness.

The data show muscle power correlated with barium but not potassium plasma concentrations.

The patient had experienced renal insufficiency, which the authors suggest may have been due to precipitation of barium sulfate. This suggests that iv sulfate should be avoided in treatment of barium poisoning.

Barium initiates or may potentiate synaptic transmission, probably by causing release of acetylcholine and any ensuing neuromuscular blockade would be expected to be depolarizing in nature. Barium also competitively reduces the permeability of cell membranes to potassium, again possibly causing membrane depolarization. Electrodiagnostic investigations showed that nerve conduction was normal suggesting that the adverse changes had occurred either in the muscle or at the neuromuscular junction. Muscle biopsy showed mild and non-specific change also suggesting the weakness may have been caused primarily by neuromuscular blockade. Results of nerve stimulation suggest that this blockade was probably depolarizing in nature.

As barium has a depolarizing effect on membranes and there was a close correlation between barium plasma concentration and the intensity of neuromuscular blockade, the data suggest barium was the direct cause of muscle weakness. There was no correlation between the degree of muscle weakness and potassium plasma concentration.

Test substance : Other TS; Barium carbonate.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (61)

Type of experience : Human – Medical Data

Remarks : This publication reports on two cases, one of which was intentional barium carbonate poisoning (the other a case of frostbite which is not summarized here).

A 29-year man took about 3 oz of barium carbonate with suicidal intention. The patient was admitted to hospital 8 hours after ingestion and on admission was fully □ariegate, feeling numbness and tingling all over the body. Serum potassium was 3.6 mEq/L. He was treated with intramuscular atropine, stomach washed with Magsulph, administered intravenous glucose and oxygen. At 17 hours after ingestion he became drowsy and developed progressive quadriplegia with paralysis of respiratory muscles. Artificial ventilation was required. About 43 hours ingestion, he suddenly developed cardiac arrest and during the next 5 hours had 17 further episodes of cardiac arrest. At 48 hours after injestion, serum potassium was 4.2 mEq/L. At about 67 hours after ingestion, the patient had the final episode of cardiac arrest from which he did not recover.

Test substance : Other TS; Barium carbonate.

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (14)

Type of experience : Human – Medical Data

Remarks : A mass outbreak of food poisoning occurred simultaneously in two settlements in northern Israel due to the consumption of sausage in which barium carbonate was substituted accidentally for potato starch. Of 144 people affected, 133 were investigated. Nineteen cases were hospitalized with one fatality. In 11 cases paralysis occurred, and in two the respiratory muscles were affected, necessitating tracheotomy and artificial respiration. The amount of poison consumed in most cases was at least 2 g.

Test substance : Other TS; Barium carbonate

Reliability : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 (57)

Type of experience : Other; Human

Remarks : This preliminary evaluation addresses the potential health hazards associated with barium at levels that might leach from glazed ceramicware. A set of specialty ceramicware, consisting of five teacups and a pitcher, was examined for extractable barium. Exposure to barium that adults (18 – 44 years) might encounter using the vessels for coffee, tea, or orange juice was estimated.

The average barium concentration for ceremicwares was 3.0 ± 0.4 mg/l (mean ± SEM). The estimated total daily intake of barium from ceramicware along with diet and water sources at the mean, 90th, 95th, and 99th percentile levels, respectively, was as follows:orange juice, 2.2, 2.5, 2.6, and 3.2 mg/person/day; coffee, 2.8, 3.7, 4.4, and 6.2 mg/person/day; tea, 2.4, 2.9, 3.4, and 4.9 mg/person/day; and coffee+orange juice, 2.5, 3.4, 3.9, and 5.6 mg/person/day. Consumers of coffee, and coffee and orange juice at the 99th percentile level exceed the RfD of 4.9 mg/person/day. As a result, adults who consume very large quantities of coffee, coffee and orange juice or tea from glazed ceramicware may be exposed to barium at levels which would exceed the RfD.

Barium exposure associated with the ceramicware item with the highest observed leachate concentration, 6.3 mg/l, at the mean, 90th, 95th, and 99th percentile levels, respectively, was as follows: orange juice, 2.5, 3.2, 3.4, and 4.6 mg/person/day; coffee, 3.8, 5.7, 7.2, and 10.9 mg/person/day; tea, 3.0, 4.0, 5.0, and 8.2 mg/person/day; and coffee+orange juice, 3.2, 5.0, 6.1, and 9.7 mg/person/day. In this case adults who drink coffee or the combination coffee and orange juice at the 90, 95 or 99th percentile levels would have daily barium intakes that exceed the RfD. Also, consumers of tea at 95 and 99th percentile levels would exceed it.

The results of this preliminary assessment indicate further study is warranted. Analysis of a broad sample of commercial ceramicware and study of barium leaching behaviour under actual conditions are needed to assess the significance of these findings.

Test substance : Other TS; Barium (The salt was not specially mentioned.)
Relaibility : (2) Reliable with restrictions
2e - Study well documented, meets generally accepted scientific principles, acceptable for assessment

21.01.2005 : (5)

Type of experience : Human – Occupational exposure
Remarks : Twelve workers were exposed to 6 % barium carbonate for several years in the production of steatite ceramics.

The evaluation of the medical history, history disease, lung functional test, blood analysis, and electrocardiogram, and X-ray (thorx, pelvis, femurs) were carried out.

The results of this study did not show clinical sign in acute or chronic barium carbonate-intoxication for workers.

Table. A distribution of workers exposed to barium carbonate in accordance with employment

No. of workers	Exposure period (year)
1	7
1	9
3	10
2	11-20
5	>20

Table. Barium concentrations in workplace

Monitoring point	Barium concentrations (mg/m^3) Date		
	12.4.1972	6.11.1972	18.5.1973
Drum filling	2.3	0.17	-
Sink	-	-	0.6
Silo and dryer	-	0.9	-

Test substance : Other TS; 6% barium carbonate
Relaibility : (4) Not assignable
4d – Original reference in language (German)
22.08.2005 : (17)

5.11 ADDITIONAL REMARKS

Type : other: summary of human barium carbonate toxicity symptoms and treatment
Remarks : The following is summarized in a section on Barium salts.

Symptoms
1. Excessive salivation, vomiting, severe abdominal pain, and violent purging with watery and bloody stools.
2. A slow and often irregular pulse due to ventricular contractions and a transient elevation in arterial blood pressure.
3. Tinnitus, giddiness and vertigo.
4. Muscle twitching, progressing to convulsions and/or paralysis.
5. Dilated pupils with impaired accommodation.
6. Confusion and increasing somnolence, without coma.
7. Collapse and death from respiratory failure, apparently due to flaccid paralysis of the respiratory muscles.
8. Cardiac arrest after periods of ventricular tachycardia and fibrillation.

Treatment.
1. rapid oral administration of soluble sulfate in water to precipitate the barium as the insoluble sulfate.
2. Gastric lavage or induced emesis, unless spontaneous vomiting is intensive.
3. Atropine sulfate (morphine in severe case to help with pain) to alleviate colic.
4. Elevated blood pressure maybe reduced with sublingual nitroglycerine.
5. When hypokalaemia has been shown, potassium salts should be administered; intravenously when vomiting is present.
6. Cardiac arrhythmias, flaccid skeletal muscle paralysis and diarrhea respond to potassium therapy. Even without demonstrated hypokalaemia, potassium administration is recommended for control of ventricular tachycardia and other tachyarrhythmias.
7. Ventricular assistance during muscle weakness or paralysis phase.
8. Rehydration with suitable solution. This will also promote renal excretion of barium.
9. Possibly a potassium sparing diuretic to promote renal excretion of barium.

Laboratory.
1. Serial determinations of serum potassium for proper management of barium poisoning.
2. ECG recording continually if possible, otherwise at frequent intervals.

Reliability : (2) Reliable with restrictions
2g - Data from handbook or collection of data

21.01.2005 (19)

(1) ACGIH, 2002 TLVs® nd BEIs® Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices

(2) Agarwal. A.K., Gupta, S., Singh, C.P and Kumar A., 1995. Hypokalaemic Paralysis Secondary to Acute Toxicity. Tropical Doctor, Vol 25, 101 - 103.

(3) Agency for Toxic Substance and Disease Registry U.S. Public Health Service, “Toxicological Profile for Barium and Compounds”, July, 1992

(4) Anderson, B.G., “The Apparent Thresholds of Toxicity to *Daphnia magna* for Chlorides of Various Metals When Added to Lake Erie Water”, Trans.Am.Fish.Soc., 78, pp 96 - 113, 1948

(5) Assimon S.A et al., Preliminary assessment of potential health hazards associated with barium leached from glazed ceramicware, Food additives and contaminants, Vol 14(5), p483 - 490, 1997

(6) Barium Carbonate Material Safety Data Sheet, MSDS No. barcarb-1003, revised 10-9-03.

(7) Barium Carbonate Safety Data Sheet (according to directive 2001/58/EC), Version 1.3, edition 28.04.2004.

(8) Birge, W.J., Black, J.A. and Ramsey. B.A., 1981. The Reproductive Toxicology of Aquatic Contaminants. Hazard Assessment of Chemicals: Current Developments, Vol 1, 59 - 115.

(9) Biesinger, K.E. and Christensen, G.M., 1972. J. Fish. Res.Board Can. Vol 29, 1691 - 1700.

(10) Borzelleca, J.F., Condie Jr., L.W. and Egle Jr. J.L., 1988. Short-term Toxicity (One- and Ten-Day Gavage) of Barium Chloride in Male and Female Rats. J. American College of Toxicol., Vol 7, 675 - 685.

(11) B.S.Khangarot and P.K.Ray, “Investigation of Correlation Between Physicochemical Properties of Metals and Their Toxicity to the Water Flea Daphnia magna Straus”, Ecotoxicology and Environmental Safety 18, pp. 109 - 120, 1989

(12) Budavari, S., O’Neil, M., Smith, A., Heckelman and Kinneary, J. The Merck Index, An Encyclopedia of Chemicals, Drugs and Biologicals, 12th Edition on CD-ROM Version 12:2, Chapman & Hall /CRC

(13) Calabrese E.J., 1977. Excessive Barium and Radium-226 in Illinois Drinking Water. J. Environ. Health, Vol 39 (5), 366 - 369.

(14) Das, N.C. and Singh, V., 1970. Unusual Type of Cardiac Arrest (Case report). A.F.J.M. Vol XXVI, 344 - 352.

(15) Dhamija, R.M., Koley, K.C., Venkataraman, V.S.M. and Sanchetee, P.C., 1990. Acute Paralysis due to Barium Carbonate. JAPI, Vol 38, 948 – 949

(16) Dietz. D.D, M.R. Elwell, W.E. Davis, Jr., and E.F. Meirhenry, 1992, Subchronic Toxicity of Barium Chloride Dihydrate Administered to Rats and Mice in the Drinking Water, Fundamental and Applied Toxicology, 19, 527-537

(17) Essing, H.G., Bühmeyer, G., Valentin, H., Kemmerer, G., and Prochazka, R. 1976, Ausschluß von Gesundheitsstörungen nach langjähriger Bariumcarbonat-Exposition bei der Produktion von Steatitkeramik. Arbeitsmedizin · Sozialmedizin · Präventivmedizin.

(18) Gerritse, R.G., Vriesema, R., Dalenberg, J.W., and De Roos, H.P. 1982, Effect of Sewage Sludge on Trace Element Mobility in Soils. J. Environ. Qual. Vol 11, 359 - 364.

(19) Gosselin, R.E., Smith, R.P. and Hodge, R.C., 1984. Section III. Therapeutic Index in Clinical Toxicology of Commercial Products, Fifth edition, Baltimore: Williams and Wilkins.

(20) Gupta, S., 1994. Barium Carbonate, Hypokalaemic Paralysis and Trismus. Letters to the editor, Postgraduate Medical Journal, p 938 - 939.

(21) Handbook of Toxic and Hazardous Chemicals and Carcinogens. Barium and Compounds, Second edition, No 13, p 104 - 105, 1985.

(22) Handbook on the Toxicity of Inorganic Compounds, 1988, p 99.

(23) Harrison, G.E., Carr, T.E.F. and Sutton, A., 1967. Distribution of Radioactive Calcium, Strontium, Barium and Radium Following Intravenous Injection into a Healthy Man. Int. J. Radiat. Biol., Vol 13, 235 - 247.

(24) Havlik, H., Hanusova, J. and Ralkova, J., 1980. Hygienic Importance of Increased Barium Content In Some Fresh Waters. J. Hyg., Epidemiol., Microbio. And Immun., Vol 24, 396 - 404.

(25) Hawley's Condensed Chemical Dictionary, Eleventh edition, p 118, 1987. Editors Sax, N.I. and Lewis, R.J. Sr. New York: Van Nostrand Reinhold Co.

(26) Heitmuller, P.T., Hollister, T.A. and Parrish, P.R., 1981. Acute Toxicity of 54 Industrial Chemicals to Sheepshead Minnow (Cyprinodon □ariegates). Bull. Environ. Contam. Toxicol., Vol 27, 596 - 604.

(27) Henrik Lilius, Boris Isomaa, Tim Holmstrom, "A Comparison of the Toxicity of 50 Reference Chemicals to Freshly Isolated Rainbow trout hepatocytes and *Daphnia magna*", Aquatic Toxicology, 30, pp 47 - 60, 1994

(28) http://ecb.jrc.it/, The European Chemicals Bureau (ECB) ,IUCLID, Year 2000 CD-ROM edition, 2004

(29) http://minerals.usgs.gov/minerals/pubs/commodity/barite/080498.pdf

(30) http://www.atsdr.crc.gov/, Agency for Toxic Substance and Disease Registry U.S. Public Health Service(ATSDR), Toxicological Profile for Barium and Compounds, July, 1992

(31) http://www.cdc.gov/niosh/rtecs/cq8339c0.html

(32) http://www.Kosha.net, Korea Occupational Health and Safety Administration

(33) Igantowicz, S., 1983. Effect of Inorganic Salts upon the Biology and Development of Acrid Mites. 1. Effect of Mineral Salts on Fecundity and Egg Viability of 'Copra Mite' Tyrophagus Putrescentiae (Schrank) (Acarina: Acaridae). Zeszyty Problemowe Postepow Nauk Rolniczych, Vol 252, 207 - 229.

(34) International Programme On Chemical Safety (IPCS), Environmental Health Criteria (EHC) 107: Barium, 1990, p 38 - 39.

(35) Izmerov, N.F., Sanosky, I.V. and Sidorov, K.K., 1982. Toxicometric Parameters of Industrial Toxic Chemicals Under Single Exposure. P 23.

(36) Johnson, C.H. and Van Tassell, V.J., 1991. Acute Barium Poisoning With Respiratory Failure and Rhabdomyolysis. Ann. Emerg. Med., Vol 20, 1138 - 1142.

(37) Johnson, D., Mehring Jr., A.L. and Titus, H.W., 1960. Tolerance of Chickens for Barium. (25866). P.S.E.M.B., Vol 104, 436 - 438.

(38) Kakar, A., Anand, I. And Sethi, P.K., 1998. Barium Carbonate Intoxication; an Electrophysiological Study. Letters, Correspondence, Book review.

(39) Kirk-Othmer Encyclopedia of Chemical Technology, Fourth Edition, Vol 3. Published by John Wiley and Sons, 1991

(40) LeBlanc, G.A., 1980. Acute Toxicity of Priority Pollutants to Water Flea (Daphnia Magna). Bull. Environ. Contam. Toxicol., Vol 24, 684 - 691.

(41) L.E. den Dooren de Jong, " Tolerance of *Chlorella vulgaris* for metallic and non-metallic ions", Antonie van Leeuwenhoek 31 pp. 301 - 313, 1965

(42) Letkiewicz F, Spooner C, Macaluso C, Borum D., 1984. Occurrence of Barium in Drinking Water, Food and Air. Prepared by JRB Associates, McLean, VA, for the Office of Drinking Water, US Environmental Protection Agency.

(43) Losee, F.L., Cutress, T.W. and Brown, R., 1974. Natural Elements of the Periodic Table in Human Dental Enamel. Caries Res., Vol 8, 123 - 134.

(44) Material Safety Data Sheet, Barium Carbonate, #100112, Ashland Chemical Co., January, 1996.

(45) M. C. Calleja, G. Persoone, P. Geladi, "Comparative Acute Toxicity of the First 50 Multicentre Evaluation of *In Vitro* Cytotoxicity Chemicals to Aquatic Non-Vertebrates", Arch. Environ. Contam. Toxicol. 26, pp 69 - 78, 1994

(46) McCauley, P.T. and Washington, I.S., 1983. Barium Bioavailability as the Chloride, Sulfate or Carbonate Salt in the Rat. Drug and Chem. Toxicol., Vol 6, 209 - 217.

(47) Merck Index, Tenth edition, p 140, 1983. Rahway, New Jersey: Merck Co., Inc.

(48) Metals and Related Compounds, Chapter 37, p 1017, 1988. In Medical Toxicology – Diagnosis and Treatment of Human Poisoning.

(49) Mumma R.O., Raupach D.C., Waldman J.P., Tong S.S.C., Jacobs M.L., Babish J.G., Hotchkiss J.H., Wszolek P.C., Gutenman W.H., Bache C.A. and Lisk D.J., 1984 National Survey of Elements and Other Constituents in Municipal Sewage Sludges. Archives of Environmental Contamination Toxicology, Vol 13, 75 - 83.

(50) Nakamoto, R.J. and Hassler, T.J., 1992. Selenium and Other Trace Elements in Bluegills from Agricultural Return Flows in the San Joaquin Valley, California. Arch. Environ. Contam. Toxicol, Vol 22, 88 - 98.

(51) National Chemical Inventories™ 2002 Issue 1, CAS Surveyor, American Chemical Society

(52) National Institute of Environmental Research (NIER), Korea, Survey on circulation volume and use pattern of barium carbonate in Korea, 2004

(53) NIOSH, The Registry of Toxic Effects of Chemical Substances RTECS # : CQ8750000, 2004

(54) NIOSH, The Registry of Toxic Effects of Chemical Substances RTECS # : CQ8600000, 2004

(55) NTP(1994) NTP technical report on the toxicology and carcinogenesis of barium chloride dihydrate (CAS No. 10326-27-9) in F344/N rats and $B6C3F_1$ mice(drinking water studies). Research Triangle Park, NC, US Department of Health and Human Services, National Institute of Health, National Toxicology Program (Toxicity Report Series No. 432)

(56) Occupational Health Guideline for Soluble Barium Compounds (as Barium), Sept 1978, U.S. Department of Labor, Occupational Safety and Health Administration.

(57) Ogen, S., Rosenbluth, M.D. and Eisenberg A., 1967. Food Poisoning due to Barium Carbonate in Sausage. Israel J. Med. Sci., Vol 3, 565 - 568.

(58) Personal communication from Solvay, May 2004.

(59) Pesticides, p C25, in Pesticide Dictionary – Farm Chemical Handbook 88. Willoughby, Ohio, Meister Publisher and Co., 1988.

(60) Peyton, J.C. and Borowitz, J.L., 1978. Effects on Ba^{2+} and Cd^{2+} on convulsive Electroshock Sensitivity and ^{45}Ca Distribution in Brain Subcellular Fractions in Mice. Tox. App. Pharmacol., Vol 45, 95 - 103.

(61) Phelan, D.M. and Hagley, S.R., 1984. Is Hypokalaemia the Cause of Paralysis in Barium Poisoning? Brit. Med. J., Vol 289, 882.

(62) Richard, J. Lewis, Sr. SAX' Dangerous Properties of Industrial Materials on CD-ROM 10th ed., John Wiley & Sons, Inc., New York, 2000

(63) Reeves A.L., 1986. Handbook of Toxicology of Metals.

(64) Roza, O. and Berman, L.B., 1971. The Pathophysiology of Barium: Hypokalaemic and Cardiovascular Effects. J. Pharmacol. Exp. Ther., Vol 177, 433 - 439.

(65) Schorn, Th. F., Olbricht, Ch., Schuler, A., Franz, A., Wittek, K., Balks, H.-J., Hausmann, E. And Wellhoener, H.-H., 1991. Barium Carbonate Intoxication. Intensive Care Med., Vol 17, 61 - 62.

(66) Shankle, R. and Keane, J., 1988. Acute Paralysis from Inhaled Barium Carbonate. Arch Neurol, Vol 45, 579 – 580.

(67) Solvay web site, July 2003, www.solvay-bariumstrontium.com/products

(68) Sowden, E.M. and Stitch, S.R., 1957. Trace Elements in Human Tissue. 2. Estimation of the Concentration of Stable Strontium and Barium in Human Bone. Cited in USEPA; Health Avisories for Legionella and Seven Inorganics, Vol 67, 104 - 109.

(69) Spangenberg, J.V. and Cherr, G.N., 1996. Developmental Effects of Barium Exposure in a Marine Bivalve (Mytilus Californianus), Environ. Toxicol. And Chem., Vol 15 (10), 1769 - 1774.

(70) Spin on The Internet, Substances in Preparations in Nordic Countries, http://www.spin2000.net/spin.html, 2004

(71) Tabor E.C. and Warren W.V., 1958. Distribution of Certain Metals in the Atmosphere of Some American Cities. Archives of Industrial Health, Vol 17, 145 - 151.

(72) Tarasenko, N.Yu., Pronin, O.A. and Silayev, A.A., 1977. Barium compounds as Industrial Poisons (An Experimental Study). J. Hyg. Epidem. Microbio. Imm., Vol 21, 361 - 373.

(73) The Metals, 4. Barium, in Patty's Industrial Hygiene and Toxicology, 1993-1994, Fourth Edition, Vol II, Part C. Edited By Clayton, G.D. and Clayton, F.E. Published by Wiley-Interscience Publication.

(74) Thienes, C. and Haley, T.J., 1972. Smooth Muscle Excitants and Depressants. Chapter 14, p 119, in Clinical Toxicology, Fifth Edition, Philadelphia: Lea and Febiger.

(75) Thomas, R.G., Ewing, W.C., Catron, D.L. and McClellan, R.O., August 1973. In Vivo Solubility of Four Forms of Barium Determined by Scanning Techniques. Amer. Ind. Hyg. Ass. J. 350 - 359.

(76) Toxicity of Group II Metals. Barium, p 63 - 65 in Metal Toxicity in Mammals, 1978, second edition.

(77) US EPA, 1984. Health Effects Assessment for Barium. Prepared for the Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington DC. Cincinnati, OH, US Environmental Protection Agency, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office (EPA 540/1-86-021).

(78) US EPA, http://www.epa.gov/triexplorer/, 2004

(79) U.S. National Library of Medicine, http://toxnet.nlm.nih.gov/cgi-bin/sis/search, Hazardous Substance Data Bank (HSDB), 2004

(80) Wallen, I.E., Greer, W.C. and Laster, R., 1957. Stream Pollution, Toxicity to Gambusia Affinis of Certain Pure Chemicals in Turbid Waters, Toxicity, Vol 29 (6), 695 - 711.

(81) Wang, W., 1988. Site-Specific Barium Toxicity to Common Duckweed, Lemna Minor. Aquatic Toxicol., Vol 12, 203 - 212.

(82) World Health Organization Geneva, 2001, Concise International Chemical Assessment Document 33, Barium and Barium Compounds

(83) Zschiesche, W., K.-H. Schaller, and D.Weltle, 1992, Exposure to soluble barium compounds: an interventional study in arc welders, Int Arch Occup Environ Health, Vol 64, 13-23.