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Scientific Reviews
of Soviet Literature
on Toxicity and Hazards
of Chemicals

Carbathion (metham sodium)

19

UNITED NATIONS ENVIRONMENT PROGRAMME

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)

INTERNATIONAL REGISTER OF POTENTIALLY TOXIC CHEMICALS (IRPTC)

USSR STATE COMMITTEE FOR SCIENCE AND TECHNOLOGY (GKNT)

USSR COMMISSION FOR UNEP

Series "Scientific Reviews of Soviet Literature on Toxicity and Hazards of Chemicals"

Carbathione

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19

CENTRE OF INTERNATIONAL PROJECTS/GKNT

Moscow 1982

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The series represents a comprehensive study of Soviet literature on toxicity and hazards of Chemicals and is published by Centre of International Projects, USSR State Committee for Science and Technology under the USSR–UNEP/IRPTC Project "Control of Hazards Posed by Chemicals to Human Health and the Environment" implemented in cooperation with the Research Institute of Industrial Hygiene and Occupational Diseases, USSR Academy of Medical Sciences.

Information carried by the review is in line with the data profile structure elaborated by the International Register of Potentially Toxic Chemicals.

The series is intended for toxicologists, higienists and all those responsible for evaluation and control of harmful effects of chemicals to human health and the environment.

CARBATHION

Carbathion (N-sodium methyldithiocarbamate) belongs to the derivatives of the dithiocarbamic acid.

Molecular formula: $C_2H_4NS_2Na \cdot 2H_2O$
Structural formula: $CH_3NHC(=S)Na \cdot 2H_2O$

Synonyms: valam, metham, methane sodium, compound 868, nemathin, trimathin, unifum.

Carbathion is a white cream-shaded crystallized substance with a sharp offensive odour. It is nonvolatile; easily soluble in water (720 g/l at 20°C); moderately soluble in methyl and ethyl alcohol, and practically insoluble in hydrophobic solvents. It is stable in concentrated aqueos solutions. In diluted aqueous solutions carbathion decomposes to evolve mephylisothiocyanate (MIT). The decomposition rate grows with the decrease of the carbathion concentration in the solution [1, 2, 3, 4, 5].

PRODUCTION PROCESS (ES)

N-sodium methyldithiocarbamate is obtained by reacting methylamine, carbon bisulfide and sodium hydroxide in an aqueous solution at 20–40°C. The aqueous solution obtained is diluted to 40%, supplemented with stabilizers (tertiary aliphatic amines) and dispensed in the form of commercial carbathion [2].

USE

Carbathion is widely used for disinfection of the soil in the open ground and in hotbed and green houses. Acting as fungicide, nematocide and herbicide, it eliminates gallic, potato and hay nematodes as well as pathogens and pests [4]. The preparation is also used for deheiminthization of sewage sediment, presowing treatment of potato, etc. [6, 7].

As a rule, carbathion is used in the form of 0.5–3% solutions (at a rate of 1.5–2 t/ha); use is also made of a more concentrated preparation (10% and 37%) [4, 7, 8].

CONCENTRATIONS

No residual carbathion was detected on an analysis of its content in cucumbers, tomato or cabbage grown in the spring period at hothouses whose soil was treated with carbathion at a rate of 200 ml/m^2 in autumn. No pesticide residues were detected either [10].

The treatment of seed potato with 35-carbathion led to an appreciable sorbing of the preparation in the skin (95 per cent). Only an insignificant part of the preparation entered the tuber at an inaffected site. The sorption on the surface was twice as much as that at the sites affected with ditilenchas, while the amount of carbathion that entered the tuber was 10–30 times as much. The content of the pesticide in the washed and dried tubers decreased within a month whereupon remained at a level equal to 40 per cent of the initial one [7].

ENVIRONMENTAL FATE TESTS

Carbathion is stable in the environment. Decomposition into nontoxic constituents takes 1–6 months. Carbathion hydrolyzes in diluted aqueous solutions to form MIT and sulfur. The hydrolysis rate declines as the temperature falls and alcalinity of the medium rises. Acids and heavy metal salts expedite the preparation decomposition [2, 5, 11]. Carbathion is nonvolatile in a moistened soil, but it decomposes to form MIT which may enter the air. The concentration of MIT in the air of enclosed hothouses reaches 40–50 mg/m^3 during the treatment of the soil with 0.5–3 per cent carbathion. The concentrations of MIT in the samples collected on the 3rd, 5th and 7th days after the treatment amounts to 1.8, 0.6 and 0.07 mg/m^3 respectively. No MIT was detected in the air on the 10th day.

The content of the preparation in the loam soil treated with the 3-per cent carbathion solution was equal to 70±5 per cent at a rate of 2.5 l/m^2. After 24 hours the content of carbathion decreased to 30±4 per cent; on the 3rd day it was 28±3 per cent; on the 4th day 15±2.5 per cent; on the 5th 3±1.4 per cent. No carbathion was detected in the soil after 6 days [12].

In deep layers of the soil, carbathion is detoxified within 2 months after the treatment at a rate of 500 kg/ha [13].

The rate of detoxication is influenced by the ambient temperature. It was shown that at an initial carbathion concentration of 5–10 mg/l, the residual pesticide ceased to be detectable within an interval of several hours to 5 days elapsed after the pesticide introduction into the soil, depending on the temperature of water (5 or 19°C) [14].

BIOCONCENTRATION/CLEARANCE/MAMMALIAN METABOLITES

Carbathion is metabolized by the body to form carbon bisulfide that partially eliminated with expired air. After administering of carbathion to albino rats at the rates of 1/2 LD_{50} and 1/10 LD_{50} carbon bi-

sulfide was detectable within 24 hours and as traces, respectively. Carbon bisulfide was not found in the air expired by rats given 1/200 LD_{50} of carbathion [24].

Rats expire up to 18 per cent of carbon bisulfide with air, while mice up to 10 per cent of the carbathion dose administered [14].

MAMMALIAN TOXICITY ARRAY

Carbathion belongs to a group of moderately toxic pesticide. The LD_{50} is 450, 320, 146 and 815 mg/kg for rats, rabbits, mice and guinea pigs, respectively with a single administration of a 37 per cent solution of carbathion intragastrically [14, 15, 17].

The LD_{50} is 7.2 g/kg and 8 g/kg for mice and rats, respectively when a suspension of crystalline carbathion in starch is administered intragastrically [20].

Carbathion has a pronounced skin-resorptive action, the skin-oral coefficient being 1.4 [5].

Acute carbathion poisoning manifests as follows: the animals become little mobile, lose appetite, poorly react to irritation; lie primarily on the side; they also show oral discharge, weakness, lid slit joining, tremor, muscular twitching, paresis and paralysis of the limbs. The death occurs within 4 days. The most characteristic feature of acute poisoning in cats is salivation [5, 15, 18, 21].

The cumulative properties of carbathion are poorly pronounced after daily intragastric administration of the preparation to rats for 6 months in a dose of 1/10 LD_{50} (45 mg/kg) and 1/20 LD_{50}. The coefficient of cumulation was equal to 11.7 and no deaths were observed in the second group of animals [5].

In daily administration of 1/5 LD_{50} of carbathion (90 mg/kg) to rats the coefficient of cumulation was 15.3 [18], while in mice given daily 1/10 LD_{50} (55 mg/kg), it is equal to 13 [15].

Administration of carbathion in a dose of 600 mg/kg to rats intragastrically results in a short-term leukocytosis, especially noticeable 12 h after the administration. No substantial differences in the morphological composition of blood were revealed between experimental and control rats given daily 1/5 and 1/10 LD_{50} of carbathion intragastrically over 4 months.

In cats administered sublethal doses of carbathion, leukocytosis reached maximum 12 h after giving the preparation. Then there was a decrease in the content of hemoglobin and red blood cells that remained unchanged for a month. An increase in Heintz bodies was recorded in the blood.

Application of a 37 per cent solution of carbathion to the skin in rabbits led to leukocytosis whose maximum coincided with the maximum inflammation at the site of application. The inflammatory process ceased as the inflammatory signs disappeared [23].

Rats given single sublethal doses of carbathion developed dystrophy of liver cells [15]. Small lymphohisteocytic infiltrates were detected in the liver of mice administered 1/20 and 1/40 LD_{50} of carbathion intragastrically [18].

Morphologic examination of the pancreas revealed dystrophic changes in the cells of islets of Langerhans which occurred in male rats given 27 mg/kg of carbathion subcutaneously for 45 days [22].

As a result of daily intragastric administration of 1/5 LD_{50} of carbathion for one month and 1/10 LD_{50} for 4 months, the rats showed a descrease in the content of SH-groups in brain and liver tissue and in blood serum.

Single administration of the LD_{50} of carbathion to rats led to a short-term reduction of the cytochromoxidase activity in the liver and ceruloplasmin in blood serum. The catalase activity of animals' red blood cells rose within the first hours after carbathion administration. No changes in metal-containing enzymes were detected on prolonged administration of carbathion to rats in a dose of 1/10 LD_{50} [5, 24].

Carbathion exerted no effect on the activity of cholinesterase in the rat blood, brain or kidneys [15, 23], but administered intragastrically it inhibited tissue respiratory enzymes in rats and mice [19].

In rats and rabbits given carbathion intragastrically in doses of 1/5, 1/10 and 1/20 LD_{50} for 2–3 months, there was a decrease in oxygen consumption, diminution of the content of codehydrogenase-I in blood and of the activity of succinedehydrogenase in rabbit tissues, an increase in the nicotinic acid content in the rat liver as well as in the cholesterol content in the rabbit blood serum and liver [14].

Intragastrically administered to rats in a dose of 1/16 LD_{50} for 15 days carbathion did not change the content of glycogen in the liver and increased blood sugar level [21].

Methylisothiocyanate (MIT) which is a volatile product of carbathion decomposition, is more toxic and hazardous than the given pesticide. MIT inhalation of the test animals (mice) in a concentration of 75–80 mg/m^3 resulted in their death. The MIT air concentration of 11–28 mg/m^3 resulted in animals' irritation. The long-term (4 months) MIT inhalation in a concentration of 1.1 mg/m^3 developed intoxication in rats which was marked by morphological disorders in the internal organs (mainly, the lungs) and certain biochemical changes (an increase of SH-groups in the blood serum, etc.).

The MIT concentration of 0.46 mg/m^3 induced, under similar conditions, minimal changes in the test animals; the given concentration of the substance was considered by the author as the minimal effective one [25].

SPECIAL TOXICITY STUDIES

Neurotoxicity/ Behaviour. Chronic 7-month experiments on rats given carbathion intragastrically in doses of 0.005, 0·5 and 20 mg/kg were made to determine the rate of production of the conditioned reflexes (defence reaction). Carbathion in dose of 20 mg/kg decelerated the formation of conditioned reflexes. Smaller doses of the preparation did not result in similar changes [14].

Acute poisoning manifested in dizziness, phobia, vegetative and vascular crises, changes in the electroencephalogram [18].

Potentiation. At the end of a 2–3-month experiment where the rats were given daily intragastric carbathion in doses of 1/20, 1/10 and 1/5

LD_{50}, the working capacity of the animals was studied from the criterion of the duration of forced swimming. 20–30 minutes before testing the rats were given alcohol. Synergism of the action of carbathion and ethyl alcohol was disclosed [ ].

Reproduction. Female rats of one of the groups were given 1/20 LD_{50} of carbathion during 4 months including the period of pregnancy; the second group was given the same dose for one month after parturition.

The conditions of the females' estrous cycle and progress in the progeny's development and growth (the number of the litter, their survival rate, average body weight, the timing of eyes eruption and the fur cover appearance, the type of fur and the animals' behaviour) were recorded. The effect of carbathion on the gonads was not detected. The number of young rats born, their weight and length did not essentially differ from those of the control animals. No pathological deviations from normal were disclosed on birth and during their development [5, 25].

Handling of 5 per cent carbathion resulted in the development of allergic dermatitis [18].

Primary Irritation. Carbathion exerts an irritating action on the skin [5]. Application of carbathion to the skin of albino rats in single and repeated doses at a rate of 50 up to 400 mg/kg entailed edema, hyperemia and formation of vesicles with a turbid contents of the place of application [15].

Instillation of a 37 per cent solution of carbathion to rabbit eyes resulted in lachrymation, hyperemia of the mucosa and constriction of the pupil. Instillation of a 36 per cent solution of carbathion induced an insignificant hyperemia of the mucosa [18].

In the people ingress of carbathion to the skin is accompanied by pruritis, reddening and formation of hemorrhagic scabs [9].

The available data testify to the fact that carbathion does not bring about the affection of the animal reproduction function.

EFFECTS ON ORGANISMS IN THE ENVIRONMENT

The data on the carbathion effect on the saprophite microflora of the river water are contradictory [15, 16]. There is information that at a concentration of the carbathion of over 1.0 mg/l, water oxygen biological consumption increases [16]. On the other hand, it was noted that at a concentration of more than 0.5 mg/l carbathion inhibits water oxygen biological consumption.

Carbathion affects the number of nitrifying bacteria in the soil, the ability of the soils to accumulate nitrates and the soil urease activity. Studies were made in biometers with three types of the soil in which carbathion was introduced annually for 4 years at a rate of 500 kg/ha. The microflora was analyzed 7, 50 and 110 days after application of the preparation. In all the soils, carbathion decreased the number of the nitrifying bacteria (by 1.5–10 times within varying observation periods) and inhibited the process of nitrification, with this process being inhibited completely during the first period after introduction of the preparation [11].

Two weeks after introduction of carbathion into the soil at a rate of 500 kg/ha, the death of intervebrate pests amounted to 90 per cent (particularly, may beetle larvae were completely lost within 3–4 days); earthworms (at the same dose) were completely lost on the surface, whereas at a depth of 30–35 cm their death rate did not exceed 25 per cent. After 2.5 months the soil mesofauna began to recover primarily at the expense of earthworms [3].

SAMPLING/ PREPARATION/ ANALYSIS

To determine the content of carbathion in the soil and foods as well as that of methylisothiocyanate in the air, a method is suggested, based on MIT absorption from the air with a mixture of one volume of 25 per cent ammonia and two volumes of methyl alcohol MIT is determined by colour reaction with a 0.1 per cent aqueous solution of sodium pentacyanoaminoferroate after removal of the solvent [25, 16].

In the course of determining carbathion residues in the vegetables by iodometry, the preparation was extracted from them by aqueous extraction [10]. In vegetables carbathion may be determined by the method based on quantitative evolvement of carbon bisulfide on acid hydrolysis whereupon carbon bisulfide is adsorbed by diethylamine and copper acetate. As a result, water-solubie copper diethylthiocarbamate, dyed yellow, is formed. The content of carbathion in the solution is determined from the colour intensity by photoelectrocolorimetry and is calculated with reference to the initial product [10].

TREATMENT OF POISONING

The treatment of carbathion poisoning is primarily symptomatic. Symptoms may necessitate the use of cardiac glucosidases, spasmolytics, calcium gluconate, diphenylhydramine hydrochloride, suprastin, rhinopharynx and gastroenteric tract lavage of German camomile, bur marigold and eucalyptus decoctions, and vitamin therapy.

On entering of considerable amounts of carbathion it is recommended that alcaline inhalations be applied [4].

RECOMMENDATION/ LEGAL MECHANISMS

In handling carbathion under conditions of open and enclosed soil it is necessary to strictly observe the safety measures. It is recommended that a gas mask or respirator with a type A gasproof canister be used for protection of the respiratory tract, and rubberized overalls, boots and gloves for skin protection. Reporting for duty is allowed not earlier than 7 days after the treatment of the soil in hotbeds with carbathion. It is necessary to use a gas mask if reporting for duty is required earlier. In the USSR, the maximum allowable concentration of carbathion (according to MIT) in the air of the working area is 0.1 mg/m^3 [4].

The maximum allowable concentration of carbathion in the air of the populated sites is equal to 0.005 mg/m^3 (maximum single) and to 0.001 mg/m^3 (mean daily).

The maximum allowable concentration of carbathion in water bodies for drinking and recreational water supply is equal to 0.02 mg/l.

REFERENCES

1. A. A. Shamshurin, M. Z. Krimer. In: Physicochemical properties of pesticides. Moscow, Khimya Pbl., 1976, pp. 158–159.
2. N. M. Melnikov. In: Chemistry and technology of pesticides. Moscow, Khimya Pbl., 1974, pp. 350–351.
3. M. V. Korablev. In: Derivatives of dithiocarbamatic acid (chemistry, toxycology, pharmacology and clinical application). Minsk, 1971, pp. 5–6, 107–108, 131–133.
4. L. I. Medved Ed. The manual of pesticides. Kiev, 1974, pp. 205–211.
5. M. F. Nesterova. Toxicological and hygienic characteristics of the soil fumigant carbathion. In: Hygiene of use, toxicology of pesticides and clinical picture of poisonings. Kiev, 1970, issue 8, pp. 362–368.
6. M. M. Chilikin. Application of carbathion to dehelminthization of sewage sediment. Meditsinskaya parazitologiya i parazitarnye bolezni, 1975, № 11, pp. 82–85.
7. Kh. S. Burstein, A.I.Vishnyatskaya. Application of the tracer method to the determination of the residual amounts of carbathion during dehelminthization of seed potato. Bulletin of the K. I. Skryabin All-Union Institute of Helminthology. 1975, issue 15, pp. 32–35.
8. V. I. Petrova, O. Z. Metlitsky, N. D. Tryakhov. Reaction of soil microorganisms to carbathion fumigation. In: Fruit growing and berry growing in the poor chernozem zone. 1979, v. XIII, pp. 144–147.
9. M. F. Nesterova. Examination of hygienic conditions of carbathion application. In: Toxicology and pharmacology of pesticides and other chemical compounds. Kiev, 1967, pp. 107–109.
10. N. A. Baran, Yu. A. Moreinik, Yu. A. Trotsky, P. I. Kolachevskaya. "Hygienic evaluation of products and water from areas preliminary treated with carbathion" Vrachebnoye delo, 1970, № 11, pp. 131–135.
11. N. B. Gersh. Inhibition of some processes of nitrogen transformation in the soil in systematic application of carbathion. Khimya v selskom khozyaistve. 1978, № 2, pp. 72–75.
12. T. M. Akishina. Preservation of residual carbathion in the soil. In: Environmental factors and their significance for the community health. 1969, pp. 136–138.
13. I. V. Shutov, N. A. Baneva, A. N. Martynov, N. M. Minakova, F. V. Naumov, B. N. Ryabinin, V. G. Yakovlev. Use of carbathion in river nurseries, Selskoe khozyaistvo. 1975, № 2, pp. 69–73.
14. S. V. Nagorny. Establishment of hygienic standards for sodium methyldithiocarbamate (carbathion) and ammonium dimethyldithiocarbamate, Gigiena i sanitariya. 1967, № 2, pp. 11–16.

15. N. A. Baran, Yu. A. Môreinis, Yu. A. Trotsky, P. I. Kosachevskaya. Toxicity of carbathion and hygienic evaluation of products and water in carbathion-treated water bodies. In: Hygiene of use, toxicology of pesticides and the clinical picture of poisonings. 1969, issue 7, pp. 103–108.
16. M. A. Klisenko, T. A. Lebedeva, Z. F. Yurkova. Determination of small quantities of carbathion and product of decomposition of methylisocyanate in the air. In: Chemical analysis of the microquantities of toxic chemicals. Moscow, 1972, pp. 259–261.
17. M. F. Lyadenko. Data on carbathion toxicity. In: Hygiene and toxicology of pesticides and the clinical picture of poisonings. Kiev, 1965, pp. 443–448.
18. L. M. Maltseva, N. I. Savaitova, L. B. Chemny. Acute carbathion poisoning. Gigiena truda i professionalnye zabolevaniya. 1971, № 7, pp. 53–54.
19. M. V. Korablev, P. I. Luklenko. Efficacy of the derivatives of dithiocarbamic acid and related compounds in hypoxia. Farmakologia i toksikologia. 1967, № 2, pp. 186–189.
20. M. V. Korablev, N. M. Kurbat. Acute toxicity of some derivatives of dithiocarbamic acid. Zdravookhranenie Belorussii. 1967, № 3, pp. 48–50.
21. I. R. Dzhaparov, V. V. Tselikov. Effect of 2,4-sodium salt on the liver glycogen content and blood sugar content in rats. In: Pharmacology of central cholinolytics and other neurotropic agents. 1969, pp. 81–84.
22. V. V. Tselikov. Effect of 2,4-sodium salt, carbathion, trichlormetaphos, nicotin and arecoline on the incretory pancreatic function. In: Hygiene of use, toxicology of pesticides and the clinical picture of poisonings. 1970, issue 8, pp. 358–361.
23. N. F. Nesterova. Changes in some morphologic and biochemical characteristics of blood in carbathion poisoning. In: Hygiene and toxicology of pesticide and the clinical picture of poisonings. 1966, issue 4, pp. 143–146.
24. P. N. Balin, M. F. Nesterova, S. S. Svetlyi. Some problems in toxicodynamics and metabolism of dithiocarbamic acid. In: Hygiene of use, toxicology of pesticide and the clinical picture of poisonings. 1968, issue 6, pp. 572–577.
25. M. F. Nesterova. Establishment of standards for carbathion content in the air of the working area. Gigiena i sanitariya. 1969, № 5, pp. 33–37.