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Uses of Boron and Boron Toxicity

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Article Info

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ABSTRACT

Boron (B) is a valuable and very important element found in many mineral forms in nature and used in many fields in the industry. B is also preferred in the field of health, especially with recent studies. It is used for the treatment of many diseases such as osteoporosis, allergic diseases, arthritis, and brain cancers. It is also possible to reach B as a nutritional supplement. There are cases where element B, which has many health benefits, is toxic. In this study, a review was made by mentioning the physical and chemical properties of B, the way it is found in nature, its usage areas, its importance for health, and its toxicity.

Bor'un Kullanım Alanları ve Bor Toksisitesi

ÖZET

Bor (B) doğada birçok mineral formunda bulunan ve sanayide birçok alanda kullanılan değerli ve çok önemli bir elementtir. B, özellikle son çalışmalarla sağlık alanında da tercih edilmektedir. Osteoporoz, alerjik hastalılar, artrit, beyin kanserleri gibi birçok hastalığın tedavisi için kullanılmaktadır. B'a besin takviyesi olarak da ulaşmak mümkündür. Sağlık açısından birçok faydası bulunan B elementinin toksik olduğu durumlar da vardır. Bu çalışma ile B'un fiziksel ve kimyasal özelliklerinden, doğada bulunuş şekillerinden, kullanım alanlarından, sağlık için öneminden ve toksisitesinden bahsederek bir derleme yapıldı.

1. INTRODUCTION

The boron (B) element is included in the IIIA group in the periodic table. Oxidation status is +3. Unlike other members of the group, it has semiconductor properties between metal and non-metal. Atomic number 5 is the atomic weight of 10,81 and is indicated by the symbol "B" [1, 2, 3]. Compound B is yellow and brown amorphous powders or solid black crystals at room temperature. Except where it interacts with strong oxidizing agents, B is a chemically inactive metal to some extent [2]. The pKa value of boric acid, which is a weak acid, is 9,2. Boric acid, such as borate salts, is insoluble in aqueous solutions (H_3BO_3) at physiological pH. Therefore, the toxicity related to these compounds is expected to be similar according to their equivalence to B. Boroxide has similar effects to boric acid because this compound is anhydrous and reacts

exothermically with water in the body, depending on its form. Boric acid can be complex with carbohydrates and proteins in the organism [3]. B reacts with cis-hydroxyl group bearing organic compounds, sugars, polysaccharides, adenosine 5 phosphate, pyridoxine, riboflavin, dehydroascorbic acid, pyridine nucleotides, phosphoinositides, glycoproteins and glycolipids [4, 5].

1.1. Presence and Sources of Boron in Nature

B is found in low concentrations in nature, but the element B, which is in the form of borate, is widely found in the earth's, atmosphere, sea, soil, underground, above water, and sediments [6, 7]. B taken from foods is generally of plant origin. These include green vegetables, fruits, legumes, fish, and mushrooms rich in boron, while meat and dairy products and boron are less common. The B element, which is spread over a wide area on earth, does not change and break down in nature but can turn into some specific forms depending on environmental conditions such as humidity level, pH, etc. The concentration of B in the soil varies geographically. It has been reported that the average ratio of B concentrations in seawater is 4,6 ppm, and boron concentrations in freshwater are between 0,01-1,5 ppm [2, 5]. Exposure to B may also occur professionally or with consumed products. In addition, underground and surface waters, wastes, mines, and factories in basins rich in B deposits can also be exposed to B [5, 7, 8].

1.2. Usage Areas of Boron

Boron is used in many fields in the industry. B and its derivatives are evaluated in many different industrial branches such as ceramic industry, sports materials, glass, cosmetics, chemistry, machinery industry, military, and armored vehicles, automotive industry, agricultural sector, textile sector, photography and vision systems, electronics and computer industry, space and aviation industry, construction sector, paper industry, pharmaceutical industry, communication tools, energy sector, rubber and plastic industry, protective, metallurgy, nuclear industry, missile fuel. Due to the antiseptic properties of B, it is preferred both as a cleaning agent and in the health sector. In waste cleaning facilities, sodium borohydrate is used to remove heavy metals such as mercury, lead, and silver from wastewater. Recently, studies on cell fuel that generates energy from sodium borohydrate have gained momentum. Boron compounds are used as armor and rocket fuel in military armored equipment. In addition, B has widespread use in many areas such as the detergent industry, cosmetics industry, use as fertilizer in agriculture (as a micronutrient), and ceramic industry. Osteoporosis treatments are used in many health fields such as allergies, psychiatry, arthritis, and brain cancers [5, 9, 10].

1.3. Boron Requirement

No definitive information on the level that may be sufficient for daily intake of B in humans has been found, but studies in animals suggest that the level that may be needed for humans may vary between 0,5-1,0 mg. On the other hand, although the amount of daily B taken with diet varies according to country and gender, there is also literature indicating that the average amount is 1,5-3,0 mg B /day [4, 10, 11, 12]. B uptake also varies according to human metabolism and age. B intake of infants is 0,75 ± 0,14 mg/ day, 1,34±0,02 mg/day for males between the ages of 51-70, and 1,39 ± 0,16 mg/day for nursing mothers. In animals, the B content of basal rations has been reported to vary between 0,16-0,45 mg/kg (feed) [13]. Humans meet their B needs by eating the richest foods in terms of B, such as vegetables and fruits, nuts, legumes, avocados, and mushrooms. The B content of meat, fish, dairy products, and most grains is low [7, 11].

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1.4. Boron Toxicity

1.4.1. Boron Toxicity in Humans

Boron exposure in humans is possible by dermal oral or inhalation. According to the data obtained from studies conducted with humans and animals, the toxicity of natural forms of B is very weak. Normal levels of B in humans are in the range of 241 µg B/L on average in the blood, 1130 µg B/L in the urine, and different concentrations in tissues are in the range of 0,06 to 1,2 mg B/kg [14].

In oral exposure, B can be easily absorbed through the gastrointestinal tract and excreted in the urine. However, destruction occurs in tissues and organs at high rates of exposure [14]. Sugar-containing compounds such as calcium fructoborate are non-toxic and quickly eliminate body surplus. Acute signs of toxicity in humans have been reported as nausea, vomiting, diarrhea, dermatitis, and dizziness, and chronic signs of toxicity have been reported as decreased appetite, nausea, weight loss, decrease in sexual activity, and decrease in low seminal volume sperm motility [14, 15]. The lowest tolerable dose of boric acid for humans is 640 mg/kg by mouth, 8600 mg/kg by skin, and 29 mg/kg by injection. B consumption acceptable to the World Health Organization has been accepted as 1-13 mg/day [16]. B uptake varies greatly between individuals and according to gender-age group [17].

The B-containing cream applied for 1 week for the rash problem seen on the skin in 4-month-old twin babies was washed with a solution containing boric acid in the problematic skin content in the second week and at the end of the second week, it was taken to the hospital with the symptoms of loose stool, sore throat, and respiratory difficulties. 1 infant death with boron has been recorded. In the analysis, the blood level of boric acid was 22 mg/L (3,9 mg B/L). 50 mg boric acid/L (8,8 mg B/L) in cerebrospinal fluid, 36,8 mg B/kg in kidney tissue, 17,5 mg B/kg in liver tissue, 2,1 mg B/kg in brain tissue and 1,9 mg B/kg in muscle tissue [18].

It has been stated that B compounds are genotoxic in the in vitro study [19]. It has been reported that B has negative effects on the reproductive system. It has been reported that seminiferous tubules cause atrophy, germ cell loss, impaired sperm motility, changes in follicle-stimulating hormone and testosterone, and decreased ovulation processes [20]. During the treatment of sprays containing compounds B and B and agricultural fertilizers, workers may be exposed to B by inhalation. Wastes with B are reported to be an element that should be taken into consideration in terms of occupational health and safety, although they do not pose a major ecological hazard [21].

1.4.2. Boron Toxicity in Animals

The toxicity of borate compounds has been extensively studied in both laboratory animals and other animals. Boric acid and borax are the most commonly tested forms of B in animals for B toxicity. Boric acid and borax showed toxicologically similar results in the animals to which they were administered [22]. Symptoms of poisoning, when taken in excess, are weakness, headache, abdominal pain, diarrhea, nausea, vomiting, muscle contraction, digestive and central nervous system disorders, impaired gland functions, and skin lesions [23, 24, 25]. The acute oral dose required for the formation of LD_{50} by the boron in rats is 4,50 g/kg, and the LD_{50} value of the boric acid administered by gavage is 3,45 g/kg. After overdose, ataxia, depression, convulsions, and death were observed in rats [26].

It has been demonstrated that high levels of B accumulation may occur in bone, muscle, adrenal tissue, brain, hypothalamus, liver, spleen, kidney lymph nodes, testis, seminal vesicles, prostate, large intestine,

and blood with excessive B intake in various animals. Inhibition of dehydrogenase enzymes in B toxicity in animals and riboflavin insufficiency decreased concentrations of metabolites such as glucose, glycogen, lactate, and ATP in the muscles can be counted [2, 27, 28]. In a study conducted on pregnant rats, it was reported that the levels that did not show a negative effect according to blood B levels were 10 mg B/kg/day and the low levels at which toxicity symptoms may develop were 13 mg B/kg/day [29]. Boric acid 125 mg /kg (c.a.) administered to rabbits has been shown to not affect growth. To investigate the dermal effects of B, a single dose of 2 g/kg borax was glued to the skins of rabbits, and the material was left in place for 2 hours. Symptoms such as anorexia, diarrhea, decreased activity, soft defecation, and nasal discharge were observed in rabbits after administration [30]. In another study, a 0,1 g dose of borax was dropped into the eyes of rabbits; severe iris irritation, corneal opacity, conjunctival redness, and discharge were observed in animals after administration [31].

It is reported that administration of a single oral dose of 1,54-6,51 g/kg borax capsule or 1,0-3,98 g/kg boric acid capsule to dogs does not cause death in animals [26]. In a study conducted on rats, it was reported that oral administration of 1g/kg of borax and boric acid caused a decrease in body weight, inhibition in DNA synthesis, and clinical toxicity symptoms in rats after the 3rd week [32].

2. CONCLUSION

B is a very common element in nature. This element, which is widely used especially in industry, has been promisingly studied for many diseases in the field of health. Today, scientific studies on B and B compounds are still ongoing. Although it is difficult to form toxicity from B taken with nutrients, it has been reported that B can cause toxicity in various tissues, damage DNA, and cause infertility. For this reason, the possible harmful effects should be investigated while benefiting from this element. More studies are needed on the boundaries of humans and other livings. Research in this field will contribute to health studies. In addition, it will contribute to the occupational health and safety of employees working in the industry.

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