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A STUDY ON HEALTH HAZARDS CAUSED BY MICROCYSTINS TO ANIMAL LIFE

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ABSTRACT

Microcystins are the cyclic non-ribosomal peptides that were produced by the cyanobacteria. Blue-green algae (Cyanobacteria) are the diverse group of the photo-autotrophic organisms and it is mostly found in the aquatic and terrestrial environments. Blue-green algae are the essential component of food chain in the ecosystems but it cause several health issues to human, animals, fish and birds. The cyanotoxins are very toxic for animals and plants including the human. Microcystins exposure will be occurred due to direct ingestion or by inhalation during the recreation, irrigation or bathing. This study discusses about the impact of microcystins and its effect towards the fish, human, animals and other livestock.

Index Terms— Microcystins, Cyanobacteria and Blue-green algae

I. INTRODUCTION TO MICROCYSTINS

Cyanobacteria are the family of single-celled algae which proliferate in the water bodies such as lakes, slow-moving streams, reservoirs and ponds. Cyanobacteria are also called as the blue-green algae. Many cyanobacteria produce the group of toxins called the microcystins and some of them are also called as toxic. The species that are commonly associated with the microcystin production is the *Microcystis aeruginosa* [1]. Toxic microcystins are mostly and actively absorbed by birds, mammals and fish. Microcystin have the characteristics that primarily affecting the liver based on the amount of toxin that absorbed. People boating, swimming and waterskiing in the contaminated water are also exposed to the microcytins.

Generally, pets and livestock will be died after drinking the water that contaminated with the microcystins. According to DeVries et al [2], one dog has died in California due to the microcystin poisoning. No human deaths have occurred due to the ingestion of microcystins. Cattle and wildlife mortalities are mostly affected due to the microcystin poisoning. This research concentrates towards the effects of microcystins in wildlife, fish and livestock.

II. CHEMISTRY OF MICROCYSTINS

Microcystins are the cyclic peptides and it contains seven amino acids. Microcystins are the several number of cyanotoxins that comprising over 80 analogs.

The following figure illustrates the general structure that shared by all microcystins.

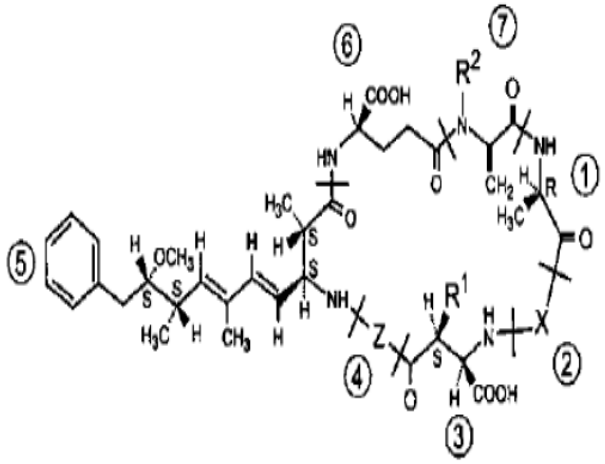

Figure: General Structure of Microcystins
Source: Lahti, et al (2001): *Occurrence of microcystins in raw water sources and treated drinking water of Finnish waterworks.* Water Sci Technol, 2001. 43(12): p. 225-8

The seven amino acids in the microcystins are numbered with variable portions X, Z, R^1 and R^2. The four microcystins have different amino acids in X and Z and both R^1 and R^2 are methyl groups. Microcystins are named with one letter abbreviation for amino acids that substituted at X and Z positions, respectively.
The following table illustrates the amino acids that appear in the structure above named microcystins.

Name	X-position Amino Acid	Z-position Amino Acid	Molecular Weight
Microcystin LA	Leucine (L)	Alanine (A)	910.06
Microcystin YR	Tyrosine (Y)	Arginine (R)	1045.19
Microcystin RR	Arginine (R)	Arginine (R)	1038.2
Microcystin LR	Leucine (L)	Arginine (R)	995.17

Table: Names of Amino Acids in Microcystins

Source: Lahti, et al (2001): *Occurrence of microcystins in raw water sources and treated drinking water of Finnish waterworks.* Water Sci Technol, 2001. 43(12): p. 225-8

The extensive toxicological information will be available for microcystin LR congener. The RR, YR and LA congeners may have similar toxicological effects. Microcystins are mostly produced by cyanobacterial cells. When the algae dies, then the cell walls will be burst by releasing the toxin into water. Microcystins will be break down slowly in the sunlight when there is some presence of water-soluble pigments [3].

III. TOXICOLOGY OF MICROCYSTINS

Toxicology is the study of the science of poisons. Here, this section discusses about the study of poisons that occurs due to the microcystins.

a) HUMAN MORTALITY AND MORBIDITY

Although no human deaths have occurred due to the ingestion of microcystins but there are number of reports about the variety of health effects due to the swimming in water and to cyanotoxins in drinking water in which the cyanobacteria were present. According to Jochimsen et al [4], liver damage is the most common sign of the human poisoning with the microcystins.
In February 1996, 116 patients were experienced visual disturbances, vomiting, muscle weakness and nausea in routine dialysis in Brazil. Nearly 100 patients were affected by the acute liver failure and also 52 patients were died eventually from the symptoms of Caruaru Syndrome. This is all because of the cyanotoxins from the reservoir water which was not filtered, treated and chlorinated. Microcystins were found in that water and also on the livers and blood of the patients.

b)LIVER TOXICITY:

Generally, microcystins are the liver toxins. Rats and mice which received the IP (intra-peritoneal) injections of the microcystin LR that is injections that directly into the abdominal cavity will be died within few hours due to the injection of

microcystins. Liver damage may include several types of liver diseases like sign of liver cell death, increased liver weight and increase in the serum of the liver enzymes. The cell death and liver damage are seen microscopically within 20 minutes followed by the injection of microcystin LR. As soon as that is within one hour the liver cells will die [5,6]. For example, the oral doses of 16.8 and 20 mg/kg was given to two mice and they were found dead within 160 minutes [7].

Microcystins that inhibit the class of enzymes called the protein phosphatases. This will remove the phosphate from protein and there are many common steps in biochemical pathways. The inhibition of protein phosphatases may cause the liver damage. Microcystins RR, YR and LA may inhibit the same phosphatases and there were histological changes in the liver as similar to the microcystin LR.

c) LIVER TUMOR PROMOTION

Microcystins are also act as the tumor promoters and it do not cause cancer but it has capacity to stimulate the cancer cells. IARC (International Agency for Research on Cancer) in June 2006, evaluate about toxicity of the *Microcystis* extracts, algal toxin and microcystin LR. IARC determined that inadequate evidence is there in the experimental animals for the carcinogenicity of *Microcystis* extracts. In addition to these, International Agency for Research on Cancer found that inadequate evidence for the microcystin LR may cause cancer in either humans or laboratory animals. Finally, International Agency for Research on Cancer could not find the evidence to conclude that the microcystin extracts will cause cancer.

Microcystin-LR will not cause cancer but the microcystin will stimulate the growth of the cancer cells. The microcystin in the drinking water may increase the weight and number of skin tumors in the mice which is treated with carcinogen dimethylbenzanthracene. The rats that treated with the diethylnitrosamine may develop the liver tumors.

IV. EFFECTS OF MICROCYSTINS ON FISH AND WILDLIFE

This section discusses about the effects of microcystins on fish and other wildlife.

a. FISH:

Microcystins are toxic to the fish at very low concentrations as very few micrograms per liter ($\mu g/L$) [8-10]. Fish generally either prey on cyanobacteria or ingest cyanobacteria [11]. According to Phillips et al (1985), generally fish will absorb toxins directly from the water. Microcystins are actively taken by the liver in fish which inhibiting the protein phosphatases [11]. Inhibition of microcystins makes fish ultimately result in the loss of liver structure or widespread cellular death.

The following table illustrates the examples of effects of sublethal oral microcystin that doses in the fish.

Fish	Dose (µg MC/kg)[1]	Number of Doses	Exposure Time (days)	Total Dose (µg MC/kg)	Sublethal Effect
Carp (adult)	2.5	16	16	40	Widespread liver damage
Carp (adult)	50	28	28	1,400	Severe liver damage
Carp (juvenile)	400	1	1	400	Severe liver and kidney damage
Trout	550	8	4	4,400	Severe liver damage
Perch	1,150	8	4	9,200	Severe liver damage
Tilapia	1,200	21	21	25,200	Significant oxidative stress in liver

Table: Examples of effects of the sublethal oral Microcystin doses in Fish

Source: Fischer, W.J. and D.R. Dietrich (2000): *Pathological and biochemical characterization of microcystin-induced hepatopancreas and kidney damage*

in carp (Cyprinus carpio). Toxicol Appl Pharmacol, 2000. 164(1): p. 73-81

Fish is most likely subject for the sublethal impacts that results from the exposure to microcystins over days or weeks. In addition to these, the effects of microcystins in fish may cause effects on gill, immune status, growth, kidney and cardiac function. According to Gotz et al [12], protein phosphatases are important during fish development and this is because they help them in regulating critical developmental processes.

b. BIRDS

Blooms of cyanobacterial species which produce anatoxin-a and/or microcystins coincided with deaths of songbirds, gulls, ducks, hawks and pheasants and also several other bird species. Several kinds of birds that killed have ranged from few to several thousand birds. Levels of microcystins that found in dead birds are similar to that of mice that exposed to the lethal levels of the toxin. According to Carmichael and Li [13], microcystin poisoning is linked to illness and mortality of great blue heron from the Chesapeake Bay.

V. CONCLUSION

This study concludes that, the blue-green algae can produce the family of toxins called as microcystins. The microcystins may cause liver damage which leads to the death in fish, dogs, cattle and other livestock. Generally, birds and fish are at risk due to the microcystin toxicity. In addition to these, no deaths have reported in humans due to the ingestion of microcystins. It is concluded that, inhibition of blue-green algae may cause primarily liver damage and also it have capacity to affect some other organs. Microcystins also act as the tumor promoter. This study concludes that the microcystis mostly occurs in quiet and warm waters which are nutrient-rich and it is mostly found in reservoirs, streams, ponds, dammed rivers and lakes and also even in the agricultural drainage ditches. In addition to these, microcystins are also been detected in Delta areas. This research concludes that most of the population in the world relies on the surface freshwaters as the primary water source for the drinking water. So, the whole drinking water industry is challenged with the surface water contaminants which must be removed in order to protect the human health and also other animals and birds. It is concluded that the animals, birds, fish or mammals that inhibit the blue-green algae will cause liver failure and it leads to death.

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