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TOXICOLOGICAL EFFECT OF HALOSULFURON-METHYL HERBICIDE WITH SPECIAL REFERENCE TO FRESHWATER FISH OF KARNATAKA, INDIA - A REVIEW.

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ABSTRACT

The agricultural sector is the world's largest herbicide user absorbing more than three billion kilograms per year. Herbicides are effective in limiting the proliferation to kill weeds, however, they have been associated with harmful human and environmental consequences. Agricultural fields account for approximately 87% of herbicide applications in India. Halosulfuron-methyl belongs to the Sulfonyl urea group and is represented chemically as C13H15N6O. IUPAC named as Methyl 3 – chloro – 5 - [(4, 6 – dimethoxypyrimidin – 2 - yl) carbamoylsulfamoyl] – 1 – methyl-pyrazole – 4 – carboxylate. This herbicide is selective and systemic herbicide that controls post emergence of sedges and other weeds. It showed activity for the eradication of annual broad-leaved weeds and nutsedges. It has an excellent foliar application efficacy against weeds especially in Rice, sugarcane, maize and bottle gourd crops. Many investigations have shown that measurable amounts of Halosulfuron-methyl have a possible impact on fish and other aquatic organisms. It has ability to inhibit acetylcholinesterase (AChE) in exposed fishes indicates its neurotoxicity potential and causes tissue damage. High Halosulfuron-methyl concentrations linked to cell necrosis evidenced by histopathological aspects. The impact of Halosulfuron-methyl concentration on the survival of various fish species in Karnataka, India, requires rapid monitoring by all sector including Government. This review gives information about the research gap in effect of Halosulfuron-methyl herbicide study and helps in further research studies.

Keywords: Agriculture, Herbicide, Halosulfuron-methyl, Groundwater, Necrosis, Neurotoxicity.

INTRODUCTION

Herbicides are extensively used in agricultural lands for the purpose to minimize the loss in the crop production. The use of herbicides all over the agricultural crops gains updated day by day but they indirectly affect the living organisms from micro to macro. The water environment is often polluted by herbicides dispersed from agricultural runoff or leaching. Herbicides entering aquatic ecosystem leads to depletion of fishes present in water. Fishes absorbs all the toxic chemicals through orally or by any opening of organs. Accumulated herbicides show seviour changes in

internal organs. They affect enzymes, proteins and molecular mechanisms that causes genetical changes, results mutation and develops abnormal development of organs leads to death. Herbicides emerged as knight armours for crops (Srivastava and Singh, 2014). In general, they are used very extensively in agriculture, forestry, public health and veterinary practices and are gaining immense importance due to their ability to control weeds, (Gagnaire et al., 2004; Jain et al., 2005; Mustapha, 2008; Naeem et al., 2010; Abu-Darwish et al., 2011) [9][10][15][16][2]. Herbicides are categorized according to their target used and covered a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematocides, plant growth regulators and others. Among these, three major classes, they are herbicides used in weed control, insecticides in insect management and fungicides in mycotic or fungal control. Herbicides have found highly toxic not only for fish but also to other organisms which observed in the food chain. Agricultural run-off near water bodies is the major cause of deposition of herbicides in aquatic ecosystem. Bioaccumulations of these herbicides threat the long-term survival of fishes by disrupting the ecological relationships between organisms and loss of biodiversity (Xie et al., 1996; Morel et al., 1998; Abedi et al., 2013)[21][14][1]. Long-term exposure of herbicides induces physiological disturbance, behavioural changes, histopathological damages, haematological alterations, biochemical changes, immune system suppression, hormone disruption, diminished intelligence, reproductive abnormalities and causes cancer (Pandey et al., 1995; Crisp et al., 1998; Brouwer et al.,1999; Mishra et al., 2006; Ullah et al., 2014; Ullah and Zorriehzahra., 2015)[17][5][4][13][19][20]. Use of herbicides has becoming increased day by day in countries like India. Unfortunately, herbicides lack target specificity and can cause severe, and long-lasting population effects on terrestrial and aquatic non-target species.

Halosulfuron-methyl is water soluble, selective and systemic herbicide for post emergence control of sedges and other weeds. It is absorbed by the root system and leaf surface, transported to meristem tissues in plants. Halosulfuron-methyl is a synthetic compound, specifically designed to target and inhibit certain plant function. It inhibits the actions of weeds acetolactate synthetase (ALS) enzymes, thus it stops growth of weeds. It can be absorbed by both roots and leaves, preventing susceptible plants from growing. It showed activity for the eradication of annual broad-leaved weeds and nutsedges. It has an excellent foliar application efficacy against weeds especially in Rice, sugarcane, maize and bottle gourd crops. It is a preferred choice among certain herbicides especially in agriculture field. Halosulfuron-methyl create a great economic loss through fish mortalities on one hand and on the other, can cause health hazards for those who utilize these fish. Halosulfuron-methyl belongs to the Sulfonyl urea group and is represented chemically as C13H15N6O. IUPAC naming as Methyl 3 – chloro – 5 - [(4, 6 – dimethoxypyrimidin – 2 - yl) carbamoylsulfamoyl] – 1 – methyl-pyrazole – 4 – carboxylate. The main mechanism of Halosulfuron-methyl chemical that interferes with the functioning of the acetolactate synthase enzyme, that finally results in cessation of cell divisions and development of plants especially in root system and in shoot system. In sulfite-sensitive human individuals, skin reactions have been observed by dermal level of exposure. Halosulfuron-methyl was registered and used in India primarily for control of weeds mainly in Rice and Sugarcane. India is one of the world's largest

producers of rice and sugarcane, it plays an important role in managing weed infestations, applied to the agricultural crops, with primary cause of soil degradation. Halosulfuron-methyl is highly toxic to green algae and duckweed aquatic plants. Significant microbial degradation in soil is also observed and causes risks to aquatic life.

Biochemical effects on rats are studied with reference to Haematological parameters. Halosulfuron-methyl was administered to rat via dose dependent manner results in a decrease in red blood corpuscles (Khozimy et al., 2021) [11] this explains that Halosulfuron-methyl also causes haematological changes if administered. This clearly explains that administered Halosulfuron-methyl causes erythropoiesis. High dosage resulted in causing effects to haematological parameters.

Enzymological effects on liver of rats are studied, Halosulfuron-methyl administered daily oral sublethal doses for 28 days. Records of blood enzymes and liver metabolic parameters were measured, in order to know the enzyme which acts highest in seviour dosgae. Halosulfuron-methyl significantly increased AST (Aspartate Transaminase) and ALT (Alanine Transaminase) activity these two enzymes play an important role in liver health diagnosis in blood parameters. Serum analysis shows that there is a highest dose of (Alanine Transaminase) is found increased.

Halosulfuron-methyl causes seviour effect on algae Botryococcus braunii, (Deng et al., 2012) [6] growth. Algae is one of the potential renewable resources for production of liquid hydrocarbons compared to other algae. Researchers used these algae for examining the effect of Halosulfuron-methyl herbicides on algal growth and their hydrocarbon contents. The acute toxicity of Halosulfuron-methyl herbicides on freshwater phytoplankton shows that there is a 50% growth reduction is clearly seen. This study explains that there is a reduction in growth of a algae is clearly observed and evidenced.

(Zaho et al., 2018) [23] studied that aquatic environment are often exposed to mixtures of herbicides. Examined single and combined toxicity of Atrazine, Butachlor, Halosulfuron-methyl and Mesotrione, widely used herbicides with different sites of action with systematic investigations to microalga Selenastrum capricornutum. After exposure of toxicants shows rapid increase in toxicity, caused by the herbicides. This is evidence that Halosulfuron-methyl also causes toxicity to microalga.

Halosulfuron-methyl causes amino acid changes in Zebra fish and it has high toxic properties to aquatic plants and animals (Zhang et al., 2017) [22]. In their research they used, Gas chromatography – mass spectrometry (GC–MS) based metabolomics approach to investigate the toxicity of acetamiprid and Halosulfuron-methyl. Identify 51 metabolites in zebra fish (Brachydanio rerio). Changes in metabolites showed that acetamiprid and Halosulfuron-methyl disturbed amino acids like Leucine, valine, serine, glycine, proline, and alanine and their metabolism, additionally TCA cycle, malic acid and fumaric acid mechanism and cascade of reactions also disturbed and in Nervous system balance of neurotransmitters like glutamic acid, taurine and glycine also disturbed. The seviour changes in liver, head and blood indicated that metabolites in the liver were more sensitive compared to found in head and blood. Overall, on the

basis of change in metabolites, researchers identified a potential risk to zebra fish exposed to sublethal doses of Halosulfuron-methyl.

(Bojarski et al., 2018) [3] have conducted a study on effects of some herbicides on fish. Researchers explains there is an alteration in numerous physiological parameters in fish, such as reduced acetylcholinesterase activity (AChE) in the brain, increased activities of hepatic transaminases and oxidoreductive balance abnormalities. Changes in hematological markers clearly suggest that there is anemia and inflammatory conditions are present. The histological changes include hyperplasia and hypertrophy of the gill epithelium, along with drastic changes in liver microstructures. Findings of the research concludes that fish are extremely sensitive to herbicides.

Halosulfuron-methyl is water soluble herbicide, detected in surface waters and fishes as study conducted by (Fathy et al., 2019) [8]. Study explains that Nile tilapia fish is exposed to this herbicide shows changes at hematological parameters that results in significance decrease in red blood cells count and significant increase in levels of Cholesterol, albumin activity of alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total plasma protein, urea, and creatinine compared to Hematological profiles. This clearly indicates that this herbicide causes decrease in haematological parameters and increase in some biochemical parameters.

Study has been conducted by researchers on Halosulfuron-methyl herbicide effects to crops especially on plastoquinone (Devendar et al., 2019) [7]. It is a terpenoid-quinone molecule that carries electrons in the light-dependent reactions of photosynthesis. Investigation reveals that there is depletion in plastoquinone. Results in reduction of carotenoid levels that leading to bleaching symptoms in crops and affects binding affinity in photosynthesis pathways. Seviour results to block plant pathways and their metabolisms.

(Li et al., 2020) [12] have conducted a study on Halosulfuron-methyl herbicide. Widely used to control sedge and broad-leaved weeds during crop production. Researchers uses proteomics and metabolomics methods to explore the phytotoxicity mechanisms of Halosulfuron-methyl against soybean. It shows physiological and phytotoxic effects that significantly reduces chlorophyll and carotenoid contents. Researchers clearly explains that, It also reduces glutathione, hydrogen peroxide and malondialdehyde contents and enzyme activities. Further on detailed investigations it also disrupts tricarboxylic acid (TCA) cycle, α-ketoglutarate dehydrogenase, isocitrate dehydrogenase, aconitase, malic dehydrogenase and succinate dehydrogenase activities and causes oxidative stress to soyabean plant.

Study has been conducted on biochemical and pathological aspects on Toxicity of Halosulfuron-methyl on male albino rats (Khozimy et al., 2021) [11]. Researchers explains in detail that how the weights of the liver, kidneys, lungs, spleen, brain and heart were measured at different increasing levels in relation to the body weight. The blood enzymes alanine aminotransferase and aspartate aminotransferase were used to measure hepatic toxicity, whereas creatinine and urea were used to detect renal toxicity. To identify oxidative damage in haematological parameters, researchers analysed haemoglobin, white blood cells (WBC) and red blood cells (RBC) in the

liver. The levels of liver enzymes rise noticeably observed. According to the researchers findings, clethodim and Halosulfuron-methyl may alter haematological parameters at subacute exposure levels.

Conclusion

Halosulfuron-methyl herbicide belongs to a chemical group of sulfonylurea. It shows significant potential impacts on terrestrial ecosystems. Which results in seviour threat to morphological, behavioral and physiology changes of fish, and also affects reproductive stability and growth success in fish. It affects plant physiological functions particularly affecting photosynthesis pathway and pH of soil. The effect of this herbicide leads to infertile land for the plants vegetations. All these evidences clearly indicates that this herbicide causes ecological imbalance. It also shows that, it has a potent to cause haematological and biochemical changes if it exposed beyond limit. It causes molecular transitional changes at molecular levels, amino acid profile changes and histopathological changes. All these evidences reveals that it causes seviour threat to aquatic and terrestrial species. Further studies by several researchers concludes that Halosulfuron-methyl herbicide causes disruption and bioaccumulation at tissue levels.

By all these evidences, it shows further detailed research investigations are needed for understanding the standard mechanisms at chronic exposure levels to aquatic life. The impact of this herbicide effects on behavioral changes, histopathological changes in different organs like gills, liver, spleen, nervous system and genotoxic studies in aquatic organisms urgently needed for conservation of environment.

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