

## Causes and Impacts of Water Pollution on Various Water Bodies in the State of Rajasthan, India: A Review

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Received 3 August 2023, Accepted 6 March 2024, Published on 6 May 2024

### ABSTRACT

Water quality and water resources make an impression on the social, economic and political advancement of society. With the rapid growth of urbanization and industrialization linked with economic and social needs, the pollution of water has reached a level of no return. Water is defined as harmful for human and aquatic lives when it is become contaminated by unexpected substances such as heavy metals, agricultural and industrial chemicals, hydrocarbon fuels, radioactive materials, sewage, pharmaceutical drugs, and biologic agents such as bacteria, parasites, and viruses. This water is considered polluted or contaminated (Bagul *et al.* 2015), The problem of water pollution becomes more hazardous in a region where availability of water is critically less like the state of Rajasthan (Coyte *et al.* 2019). The situation of surface water pollution in arid and semi-arid areas of state is alarming. We know that every living being needs water for their survival. All living being intake water

directly or indirectly from various water resources. Intake of polluted water would be harmful for them. Transport of bio-accumulative pollutants to food chain makes the situation more grievous. So, it is the need of the hour to examine the magnitude and range of water pollution in the water bodies, especially in the state like Rajasthan. In the present scenario we can't prevent water to being polluted totally but the scaling down of pollution is imperative. It is high time to take some steps to educate and spread awareness to the people regarding this alarming issue.

**Keywords** Ecological contaminants, Environment pollutions, Water pollution, Water quality, Water resources.

### INTRODUCTION

Clean and potable water is necessary for maintenance of life. Water is not only an important environmental need for all forms of life, but it also plays a significant role in socio-economic advancement of human population (Praveen *et al.* 2016). Water is a basic part of every living being and it is required to fulfill various types of needs in every stage of the lifecycle. Other than drinking, water is used for cleaning, food processing, industrial operations, and agricultural work. Water has always been one of the most essential entities for survival of living systems almost since the evolution of life form. Studying water systems is very important for improving water quality because it can have a big impact on living systems, either directly

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or indirectly (Bhattacharya *et al.* 2018). Resources related to water is very important for maintaining sufficient food source as well as a productive environment for all the living organisms. With the growth of human populations and economies, global freshwater demand has been increasing quickly. With the threatening of the sources of food supply, water shortages severely lower biodiversity in both aquatic and terrestrial ecosystems (Kılıç 2020). The most vital and vulnerable freshwater system are the river, lakes, ponds, and traditional storages like johads, nadi plays a significant role in the sustenance of all life forms. The downfall in the water's quality in freshwater systems threatens its sustainability and has become a cause for concern (Venkatesharaju *et al.* 2010). Water is the very precious resource and highly rich substance that covers the surface of the Earth approximately 71%. Only 0.5% of the total water on earth is easily available for human use. There are many different places where this water can be found, including ice caps, ponds, lakes, reservoirs, rivers, streams, and rainfall. Seawater makes up 97% of all water on Earth, and desalination is the only process that can make it usable. The remaining 2.5% is freshwater which is present in the form of ice cap or stored as ground water (Baker *et al.* 2016). Water pollution has become a grave environmental concern in India and specially a desert dominant state like Rajasthan. Its impact has traditionally been related to public health risks. As estimated approximately 70 % of the receivable surface and ground water is polluted because of inappropriate disposal of untreated sewage, domestic wastes, agricultural wastes and industrial wastes directly into rivers, lakes and streams (Rakhecha 2020).

The primary causes of water pollution are atmospheric deposition, radioactive waste, leaks from water tanks, and the discharge of effluent wastes. Industrial waste and heavy metal disposal can build up in lakes and rivers, dangerous to the health of people and animals. The main culprits behind immunological suppression, impaired reproduction, and acute poisoning are toxic elements found in industrial waste. Infectious diseases like cholera, typhoid fever (Juneja and Chaudhary 2013) and other diseases like gastroenteritis, diarrhea, vomiting, problems related to skin, and kidney spreads through polluted water (Khan and Ghouri 2011) affecting human health.

Various water pollutants are the reason for killing of sea weeds, aquatic birds, fishes, crustaceans and other aquatic organisms that serve as food for human. Concentration of bio-accumulative pesticides like DDT concentration in water resources is amplifying along with the food chain. These pesticides are dangerous for human health (Haseena *et al.* 2017).

Water quality is categorized into different grades according to the parameters to pollution levels. (Xu *et al.* 2014). The physical parameters of water quality are- turbidity, temperature, color, total solid, taste, odor, electric conductivity (EC) and chemical parameters of water quality includes pH, acidity, alkalinity, residual chlorine, sulphate, fluoride, nitrates, dissolved oxygen (DO), biochemical oxygen demand (BOD), radioactive substance (Omer 2020). Therefore, water quality assessment involves analysis of various physico-chemical, biological and microbiological parameters that shows the biotic and abiotic status of ecosystem (Rao *et al.* 2012).

### Methodology of the study

This paper is mainly based on secondary sources of information that includes the data available in various academic journals, books, and publications of the government and other nodal agencies related to water resource conservation. Main methodology of the study may be outlines as:

- 1 To identify the causes and sources of water pollution on water resources in Rajasthan
- 2 To know impacts of water pollution on various water resources in Rajasthan
- 3 Conclusive remarks

### Causes of water pollution in Rajasthan

Water quality in the desert state of India Rajasthan is afflict by the coexisting presence of both naturally occurring and man-made pollutants. Naturally occurring hazardous minerals (Coyte *et al.* 2019) which are being summarized here.

**Human-made (Anthropogenic) pollution :** Human activities affect both water quality and quantity. It changes land use and land cover, that leads to the

water balance and usually changes the relative importance of processes that control water quality (Coyte *et al.* 2019). Man-made or anthropogenic water contaminants such as drain aside from home sewage and agriculture, feces of animals, various pesticides, fertilizers of agriculture, radioactive wastes, erosion of lands near by water bodies are fouling the existing water resources. All these pollutants are harmful for both aquatic and human lives (Coyte *et al.* 2019). For instance, in Rajasthan there are bunch of textile printing units releasing waste that contains dyes leading to heavy metal contamination of groundwater and surface waters (Husain *et al.* 2013). Jaipur, Pali and Bhilwara Districts are the major hubs of textile printing units in Rajasthan. Pollutants added to water resources through such anthropogenic activities comprise organic material, trace elements (heavy metals), atmospheric acidic deposition and runoff, salinization, nutrients like primarily nitrogen and phosphorus, pathogenic agents including coliform like bacteria, viruses that infect the intestines, protozoa, oil and grease, suspended sediment, synthetic organic compounds, pesticides and herbicides of agriculture, radioactive residues and thermal pollution. Each human activity that produces such contaminants has a potential cascading and cyclical effect on water quality and quantity (Peters *et al.* 2006). Arsenic, cadmium, and chromium are among the prominent pollutants discharged in wastewater from industrial units and dreadfully harmful pollutants (Chen *et al.* 2019). Wastewater from human activities like from industries, agriculture, and other practices, affects water quality. It impedes not only the use of water for drinking purpose but also make it unfit for agriculture and other utilization (Baluch and Hashmi 2019).

**Natural causes of pollution :** The natural contaminants are thought to be natural and have delayed health effects, they can go unnoticed. Examples of these include uranium and fluoride, which are found in aquifer rocks. The processes like evapotranspiration and water-rock interactions that affects the quality of water resources in Rajasthan are common in many other worldwide arid areas. Hence, the lessons learned from analysis of the mechanisms that affect the surface water quality are same in worldwide. The biodegraded part of both vegetation and animals gets mixed with water and pollute it. Erosion of riverbanks

causes siltation and that sometime affects the aquatic lives. Many kinds of natural salts and other substances mix with rainwater and finally fall in the rivers, ponds and other water bodies (Chakraborty *et al.* 2013). Natural processes influence the surface water and groundwater quality by various events and factors like climate changes, natural disasters, geological formations, soil-matrix, and hyporheic exchange (Akhtar *et al.* 2021).

According to the published reports natural causes of water contamination able to categorized as into the following categories:

- a Climate change
- b Natural disaster
- c Geological factors
- d Soil matrix
- e Industrial waste

**Climate change :** Prevalent, fast, and intensifying climate change plays an important role in determining the characteristics of water resources and so can alter the quality of the available drinking water. According to Baiwen *et al.* (2022) continuous emission of greenhouse gases influence the source water quality on a mandatory basis, and little attention has been paid to the resulting impacts of climate change on the related drinking water quality, particularly on quantitative findings and the possibility counteractions. Lack of water and worst water quality can also impact human health, especially in drought conditions (Baiwen *et al.* 2022).

**Natural disaster:** Water pollution is mostly caused by the enormous number of wastes released by natural disasters like flooding, tsunamis, hurricanes, tornadoes, and volcanic eruptions (PAHO 1998). Flooding and other natural disasters have the potential to destroy drinking water wells and contaminate them with chemicals, animal and human waste, human sewage, livestock waste, and other contaminants (Sholihah *et al.* 2020). Large amounts of contaminants in surface water resources are also a result of natural hazards. The parameters of the water supply can be impacted by numerous pollutants, including lead, total dissolved solids, chlorine, nitrates, faeces, and coliform. (Euripidou and Murray 2005).

**Geological factors :** Numerous minerals that break down in geological formations trigger variations in water quality over time and space, which in turn affects human and environmental health. With regard to this, water-rock interactions in modified areas of Nowadays, geological units have been considered to be the primary factors impacting the quality of water resources. The Pre-Cambrian Aravalli system supports the geological structure of many districts in Rajasthan, and the degree of fluoride contamination is correlated with the hydro-geo-chemical process that mobilizes fluoride according to Ninama and Mishra (2018). According to Keshari and Dhiman (2001) mapping of the study area shows a strong positive correlation between fluoride and ultrabasic rock. It is the phenomena with other parameters also. The local population's various health consequences from consuming such contaminated water are primarily caused by these interactions. Higher levels of certain elements, such as fluoride and arsenic, could be harmful to major illnesses like internal organ cancers, Alzheimer's disease, mesothelioma, fluorosis, thyroid goitre issues, and several others have been linked to human health (Baba and Gündüz 2017).

**Soil matrix :** The physical characteristics of the soil or sediments matrix regulate water flow and affect groundwater aquifer storage (Winter *et al.* 1998). The quality and the volume of water flowing through Rajasthan's inland waters are determined by the complex interaction of human activities with soil and climate (Swain *et al.* 2022). The mosaic of soils that characterize the catchment draining a waterbody that regulates the water's flow through a catchment and the movement of nutrients and contaminants (Daly *et al.* 2018).

**Hyporheic zone exchange :** The procedure of solute mixing between the exchange area and the near-channel and in-channel water exchanged by surface water and groundwater through streambed sediments within rivers which are alluvial (Brunner *et al.* 2011). For karstic, confined, and fractured hard-rock aquifers, flow and recharge primarily occur inside networks of fractures, cracks, and other isolated openings allowing for both quick and slow recharging (Schmadel *et al.* 2016).

### **Water pollution's source in various water bodies in Rajasthan**

The major sources of water pollution in various water bodies in Rajasthan that result in contamination are direct and indirect ones, in addition to other sources.

When hazardous pollutants are mixed with water directly into a water body or contaminated water is released by an industrial facility into the water, that is referred to as direct pollution. Due to this, the water is toxic and poisonous. quickly, frequently leading to fish and other aquatic life's demise. Yet, animals who consume this water can get ill and possibly die. Humans may also be impacted by it. In addition, being hazardous for swimmers, this polluted water can be extremely sickening (Singh *et al.* 2020).

On the other side individuals who wind up in the water cause indirect water pollution rather than the water itself being directly contaminated. For example, agricultural fertilizer and insecticide chemicals that are washed slowly through the soil and find their way into groundwater and then into various waterbodies. From above, air pollution can cause acid rain to fall to the ground, which can be extremely harmful to wildlife, including polluting lakes, streams and shores, and make the water deadly for those organisms that leave in and near it (Singh *et al.* 2020).

According to Carpenter *et al.* (1998) sources of water pollution may be classified in following categories.

#### ***A Direct or point source:***

- 1 Municipal and industrial wastewater effluent
- 2 Run of from oil field, various mines and unsewered industrial sites
- 3 Runoff from various construction sites
- 4 Infiltration and runoff from animal feedlots
- 5 Overflow of combined Storm and sanitary sewers

#### ***B Indirect source or non-point source:***

- 1 Agriculture run off encompassing the flowback from irrigated farming
- 2 Land activities generating contaminants

- 3 Runoff from range and pasture
- 4 Atmosphere deposition over a water body
- 5 Urban run-off sewerage and un sewerage area with a population less than 100000
- 6 Run-off from septic tanks, abandoned mines

### **Some of the important sources or causative factors of water pollution**

In continuation from both point and non-point sources water pollutions listed above, the major sources or causative factors for the same in reference to the state of Rajasthan is being summarized here.

#### ***Urbanization***

With the increasing population, urbanization and industrialization there is steady increase in surface water drift in Rajasthan. The less availability and distribution of the surface water bodies puts extra pressure on other water resources, and this has resulted in their over-exploitation by growing population. A growing population frequently ends in patterns of extensive urban sprawl, which can contribute to pollution of surface waters (Kumar 2020). Surface water bodies are adversely affected by untreated sewage and polluted urban runoff, making them unfit for use as a freshwater source for urban needs. Urban surface and groundwater are severely contaminated by sewage littering and effluent from solid waste landfill sites (Agrawal *et al.* 2021). Animal wastes, leachate from solid waste, domestic wastewater leaks in drains, effluent from septic tanks, soak pits, pit latrines, and other the sources pollute surface and groundwater quality garbage disposal location (Dhanial and Rani 2014).

#### ***Sewage and other oxygen demanding wastes***

The daily generation of large amount of non-biodegradable and organic wastes management is not successful in general. Due to this, waste is disposed of carelessly in the majority of India, which eventually rises the number of contaminants in surface and groundwater resources (Kumar 2020). Sewage and fertilizers can cause a huge increase in the growth of algae or plankton that facilitate large areas of ponds, lakes, or rivers creating a condition that is known as

algal bloom (rapid increase of algal population) thus reducing the dissolved oxygen content of water and killing other forms of life like fish (Chislock *et al.* 2013). The combination of contaminants found in sewage discharge includes heavy metals, pathogens, hormone disruptors, and pharmaceuticals in addition to feces and fecal viruses (Wear and Thurber 2015, Wear *et al.* 2021). This results in heavy load of foul contaminants in water resources.

#### ***Industrial wastes***

Industrialization is becoming a main plank of the state economy of Rajasthan and along with the socio-economic growth the environment has also been impacted (Sharma and Meena 2017). There are numerous places in Rajasthan that are near rivers, lakes, and ponds where industrialization has advanced much faster than the capacity of regulators to impose significant restrictions on the amount of point source pollution allowed to the various industrial complexes. Cement, chemical, fertilizer, textile, mining, quarrying, dyeing, and printing factories are examples of such industrial units (Rajput *et al.* 2017). The pollutants generated from these industrial units are threat to the ecology and existence of nearby waterbodies (Rajaram and Das 2007).

Many industries directly discharge their waste into lakes, rivers and nearby ponds. Insecticide, various chemicals, waste oil and heavy metals are regularly brought into the waterbodies. Polluted waterbodies may enable heavy metals to bioaccumulate into people and other organisms. Industrial waste can be hazardous, flammable, corrosive, or reactive (Yadav *et al.* 2016). Industrial wastewater also contains organic materials, pathogens, metals, salts, ammonia, pesticides, pharmaceuticals, endocrine disruptors (Yadav *et al.* 2016). Effects of industrial water pollution is detrimental to the health of animals including humans and plants. It may cause severe kinds of diseases. Physico-chemical factors of water including pH, light, turbidity, and temperature of water bodies, are also affected due to industrialization (Arif *et al.* 2020).

#### ***Agro-chemical wastes***

The encouragement to grow more food has made humans more dependent on use of agrochemicals

like pesticides and fertilizers. While the careless use of agrochemicals has boosted crop yields, it has also seriously endangered the environment by polluting natural resources like groundwater. Different kinds of particles and sediments get released into surface and ground water systems as a result of agricultural practices (Gupta and Khanna 2018).

In Rajasthan a large area of catchment of various water bodies is used for agriculture and for vegetable crops. This cultivation leads to input of agrochemicals particularly pesticides, fertilizers, herbicides and insecticides widely used in crop fields to increase productivity. The purity of the water in lake and other water sources can be polluted by synthetic pesticides and other agro-chemicals (Sharma 2015). Uncontrolled use of pesticides and herbicides in agriculture may alter the quality of products and bioaccumulate in higher levels of trophic structure, similar to how humans can change the activities of different enzymes in body, resulting in a number of health issues (Abdollahdokht *et al.* 2021). Chemicals such as pesticides interact with water differently according to their chemical and physical characteristics. The primary components of all pesticides are combined or dissolved in inert substances to modify their focus. Therefore, the presence of fillers, impurities, and/or intermediates during the degradation process may also be the cause of water pollution in agricultural systems (Rad *et al.* 2022). Considering their high concentration of nutrients like phosphorus and nitrogen, fertilizers may also be to blame for agricultural water pollution. When fertilizers are used excessively, they remain in the soil particles. Rain washing removes it, and irrigation water making its way into water supplies. Since they are less soluble than nitrates, phosphates can be adsorbed onto soil particles and cause soil erosion, which pollutes water (Rad *et al.* 2022).

### ***Thermal pollution***

Changes in water temperature adversely affect water quality and aquatic biodiversity. Majority of the thermal pollution in water is caused due to human activities like thermal power plants. Nuclear power and electric power plants, oil refineries, steel melting factories, coal-fired power plants, and various other facilities are some of the major sources of thermal

pollution.

Waste heat losses from electrical power plants' inefficient generation raise the temperature of cooling water from 5.6 to 16.6 degrees, which spreads to other nearby water bodies (Shiomoto and Betty 1978). The raised in heat contributes to the physical, chemical and biological changes in the nearby receiving water bodies. Thermal pollution from power plants degrades riverine ecosystems with ramifications beyond the natural environment as it affects power supply. Because the movement of thermal effluents along river reaches raises the temperature of condenser inlets downstream, it may cause interferences among plants.

Miara *et al.* (2018) reduction in dissolved oxygen (DO), Interference in biological activity, Interference in reproduction, increase in toxicity in water, Direct mortality of aquatic animal are the major effects of thermal pollution (Vallero 2019).

### ***The disruption of sediments***

Construction of dams for hydroelectric power can reduce the sediment flow affecting adversely. Increased sediment flow can also create various problem. Large amounts of dirt, rock, and other fine particles may occasionally make their way into adjacent waterbodies during construction, turning the water dark or silted. The excess silt may obstruct fish gills, suffocating them in the process.

Fine-grained materials like clay and silt are known as sediment, and they usually remain over after soil erosion. Sediment enters rivers and lakes when rainfall erodes a muddy bank or washes away bare soil. These tiny particles are present in the environment naturally, but when huge quantities of particles get into adjacent water systems, problems happen. Turbidity in waterways is caused by finely suspended particles. Stated differently, they obstruct sunlight by decreasing the transparency of the water. The growth of aquatic plants—which serve as many aquatic animals' basic habitats, including young fish and other aquatic creatures—will be hampered by the reduced light. (<https://www.treehugger.com/water-pollution-sediment-1204128>)

### *Natural source*

The natural entry of pollutants in water reservoirs can be done through various activities as given below.

**Rain water:** Rain dissolved pollutants in air and bring down to the earth surface. Because of acid rain water get polluted and toxic and can affect to fresh aquatic life, damage to plants leaves, change in rate of photosynthesis in the plants and it also extensive damage to historical structural building, the PH of the soil changes which affect its fertility. Therefore, it is essential to control pollution, and in order to control pollution, it is required to determine whether or not the observation zone is polluted (Gaddamwar 2011).

**Due to atmosphere like dust and storms in Rajasthan:** Dust storm is the natural phenomenon occurring very repeatedly in the desert areas and causing considerable environmental degradations in the desert lands. Regions those dependent primarily on agriculture is facing extreme challenges for ground water, irrigation and other sources of water because of the direct impact of dust storm and desertification (Ghosh 2014).

**Natural run off :** Various types of runoffs for water pollution include agricultural lands with grazing and grasslands, forest watersheds, barnyards and feedlots, wasteland and storage facilities in the form of seepages or discharges, and construction sites (Khatri and Tyagi 2015).

**Surrounding vegetation :**Due to falling of leaves, twigs and other parts of surrounding vegetation water can be polluted.

### **Impact of water pollution on water quality of various waters bodies**

#### ***Impact of pH***

For optimal growth and survival aquatic organisms needs the pH of their water body to be within a certain range. Even though every organism has an ideal pH, the pH range that most aquatic organisms prefer is between 6.5 and 8.0. When an organism is outside of this range, physiological stress occurs. Reproduction

that is outside of the pH range may be affected, and in fact, if the pH falls too far from its ideal range, organisms could die. Low pH level can cause the release of toxic elements and compounds from sediments into the water where they might be picked up by aquatic animals or plants. The availability of plant nutrients, such as phosphate, ammonia, iron and trace metals, in the water can also influenced by changes in the pH level (Ben-Chioma *et al.*). Bitter drinking water, blocked water pipes, and a reduction in the effectiveness of disinfecting agents like chlorine are all caused by raised pH levels. Increased values of pH cause metals to corrode or dissolve in water, thereby raising the toxicity levels and hence lowering the quality of the water (Zhen *et al.* 2016).

#### **Impact of storage of DO (dissociated oxygen)**

The organic matter content of wastewater is expressed as chemical oxygen demand and biological oxygen demand. The dissolved oxygen content of water is important for survival of aquatic life. Dumping a lot of organic waste into lakes, rivers, and coastal areas impacts plants, fish, and other aquatic animals (Kulkarni 2016).

Due to the discharged of heavy sewage pollution and effluents containing high organic matter into any water body reduced greater amount of dissolve oxygen level. DO are also broken down by the physiological activity of microorganisms by using dissolved O<sub>2</sub> (Kulkarni 2016).

#### ***Impact of trace elements/ ions (Eutrophication)***

The eutrophication effects water quality directly or indirectly. Water pollution from domestic sewage increases the organic load in waterbodies. Also, pollution from agricultural runoff containing huge amounts of nutrients like potassium, nitrates, phosphates, make fertilize the water and raise the rate of productivity of the aquatic ecosystem. This all-process results in the complex growth of phytoplankton waterbodies. Due to extreme growth of phytoplankton. Water becomes Turbid and suspended particles by soil erosion. Due to the eutrophication and organic pollutants dissolve oxygen depletes from water body with a rise in the CO<sub>2</sub> level, due to decomposition of undecomposed

organic matter (Malik *et al.* 2020).

### ***Impact of climate change***

Climate change affect water quality and even water ecosystems, and specific effects vary among different regions and different types of water bodies (Xia *et al.* 2015). Climate change possesses the potential to directly or indirectly affect water quality and even water ecosystems through a variety of biochemical processes (Dalla Valle *et al.* 2007).

Water bodies in the State are scarce and have been highly random distribution both spatially and temporally. Climate change causes further stress in specific areas then it becomes extremely important to have appropriate water management strategies to deal with these type situations. Thereby important to understand and determine impact of climate change on various parts of the state's waterbodies and to determine the modalities to deal with this type future scenarios of climate change (Tiwari *et al.* 2013).

### ***Impact of depth and flow (Siltation)***

The three most visited lakes in Rajasthan are Jal Mahal, Jaisamand, and Udaisagar among the nation's water bodies with the worst contamination. Known as the "City of Lakes," Udaipur's majority of its water bodies are severely contaminated and overrun. Pichhola Lake, a significant drinking water source, is likewise dealing with the same issue. The main problem in all of these waterbodies is siltation. Because of siltation brought on by land erosion, the waterbody's ability to hold water as well as its flow have both decreased (Rajasthan losing lake wealth : The Tribune India.

### **CONCLUSION**

The various data and information presented here indicate the causes and impacts of water pollution on various water bodies in Rajasthan. Surface water of Rajasthan's various water bodies are polluted by industrial effluents waste, different agro-chemicals, domestic and sewerage dirt, sediment, thermal pollution Maximum industries excrete toxic substances to water bodies. Some sources spread germs and

caused diseases. Excess use of fertilizer in agriculture caused water pollution by supplying nutrient for unexpected plants which finally causes depletion of DO through eutrophication. Most of the nitrates of urea goes through the soil to the ground water. Silt and sedimentation refrains sun light from passing through water to the aquatic plants. Due to this, photosynthesis cannot take place. Dissolved Oxygen is very much necessary for aquatic animals. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) increase means substances which consume oxygen from water increases in water bodies. Therefore, higher the BOD and COD mean lower the DO and more danger for aquatic animals. Components of pesticides, specially chlorinated pesticides are hazardous water pollutants. They can affect human nerve system accumulating through food chain.

### **ACKNOWLEDGMENT**

The author acknowledges the faculty and research fellows of Department of zoology, Government PG College Sirohi, Rajasthan for the presented work.

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