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A study on relation between phytoplankton and heavy metal pollution in Dravyavati River, Jaipur, India

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Abstract

Adverse consequences are the result when polluting contaminants are introduced into a natural environment. Water pollution is usually the result of untreated discharges of sewage, industrial effluent, oil spills and agricultural pesticides. Human activity involved in toxic metals processing and manufacturing of organic pollutants has dramatically increased contaminant levels in aquatic systems and soils. Algae normally occur in fresh water, and some species thrive in saltwater. Algae are valuable monitors of conditions in an ecosystem because they are exceptionally responsive to changes in water chemistry and tolerant of the variety of conditions; both the assortment of species and their density reflect the prevailing water conditions. Algae also play a role in the purification of wastewater because they can absorb a variety of harmful substances in their cells. Chief among these are heavy metals, organic and inorganic toxic substances, pesticides, excess nitrogen and radioactive materials.

Keywords: Sewage, Indicator, Ecosystem, Heavy metals.

Introduction

Water dominates the Earth's surface, covering 70% of it. Water pollution is any chemical or physical substance introduced into a body of water that degrades the original quality of the water. The degraded quality can affect the health of all life forms in or around the polluted environment. The damage, which usually results from the careless discharge of untreated biological, mechanical or chemical waste, can contaminate drinking water, reduce the reproductive success of plants and animals, and increase biologic mortality rates. Remediation – before, during or after discharge – is the only effective strategy to combat pollution released into the environment[1].

Multiple forms of pollution – municipal, agricultural or industrial – are capable of reducing water quality. Water is a vital resource because all living organisms require it to survive. Earth's freshwater resources are easily the most critical, as they are most accessible to humans for daily life and practical agricultural and industrial utility. Contaminated water is unacceptable for drinking, farming or industry. The most common forms of pollution are municipal sewage, agricultural runoff of nitrate fertilizers, pesticides, insecticides and herbicides, and industrial discharges of hot water, solvents, petroleum compounds, and other chemicals[2]. Pollutants present at higher land elevations either soak into the ground in place, or inevitably drain down gradients into streams and rivers where they accumulate and concentrate in standing bodies of water, such as ponds and lakes, which can lose their delightful character and become industrial wastelands[3,4].

Release of untreated sewage into rivers sets the stage for the appearance of water-borne diseases. Grey water (municipal sewage water) needs to be recharged into the ground after proper treatment to allow soil filtration. Untreated industrial discharges create their own set of far-reaching downstream ecosystem problems. Most industries use large quantities of water, and use it in an infinite number of varied industrial processes. This water is habitually exposed to a variety of harmful, toxic substances including heavy metals, dangerous chemicals, petroleum compounds, radioactive waste and organic sludge[5]. Typically, the used water is discharged, untreated, into flowing or standing water.

Therefore, all downstream users are facing the prospect of consuming water whose purity cannot be guaranteed. Farmers, on the one hand, will be accessing water already carrying an unspecified pollutant load, and will use it to grow crops whose quality can suffer. Additionally, the same farmer will contribute to the regional ecosystem problem by allowing uncontrolled runoff of his nitrates, pesticides, insecticides and herbicides. By the same token, in the simplest circumstances where the quality of incoming water is not of great concern, industrial users in the same regions will be relying on (and recycling) degraded water of dubious quality. In more sophisticated circumstances, where the sourced water needs to be uncontaminated, the industrial concern will either have to remediate its own water or look further afield to guarantee a clean supply. In either case, municipalities, farmers and industries find themselves relying on water sources from degraded ecosystems[6].

Industrialization is the period of commercial and financial trade that transforms a human settlement from a rustic culture into a modern one. India began industrializing after independence in 1947. Its industrial policy began in 1948 with the announcement of a formal industrial policy[7].

Rajasthan, the largest State in India, constitutes 10.4% of India's total area. Administratively, it is divided into 7 divisions, 33 districts, 244 tehsils, 249 panchayat samities and 9,168 gram panchayats. Rajasthan accounts for 3.8% of the factories in the industrial base of India. In a recent calendar year (20111-2012) 272 factories were added to its industrial census. Only Gujarat and Uttarpradesh contain more.

Numerous areas in Rajasthan are undergoing ecosystem damage from contamination of the available water supply. Much of this damage is the result of human carelessness in disposing of wastes and industrial products. The uncontrolled introduction of natural and synthetic compounds into the aquatic environment can seriously degrade the quality of soils and water, and harm the resident human population. Plants and animals are also impacted negatively by the effects of water pollution but some animals, such as aquatic worms, leeches and snails, are highly tolerant of pollutants[8]. On the other hand, plants such as algae exhibit a variety of responses to pollution, with some easily affected adversely, and others showing high tolerance.

Jaipur (26.9124° N. Lat., 75.7873° E. Long.), a city centrally located in Rajasthan, is undergoing rapid urbanization and industrialization. In most parts of Jaipur, and in all its surrounding areas, many industries have spring up during the last 20 years, creating a colorful tapestry of industrial activity throughout the city. These areas include Bais Godown, Jhotwara, Malviya, Mansarovar, Sanganer, Sitapura and Vishwakarma, and contributed to creating a colorful caricature of sundry areas of this city. These areas include Bais Godown, Jhotwara, Malviya, Mansarovar, Sanganer, Sitapura, Sudershanpura and Vishwakarma[9], which are now playing a crucial role in polluting different water resources. In the graph of polluted waterways, Dravyavati River (also known as the Amanishah Nala is the leading offender. Dravyavati River and other recharge areas need to be clean and pollution-free.

Dravyavati River is considered the lifeline of Jaipur and its typical perennial water flows decrease substantially during the summer months. This Nala flows in the central part of Jaipur. Today, the sewage content has risen by 75% and the sludge content has risen equally sharply. As the principal drainage artery in the city, Dravyavati River is overwhelmed by the burden of domestic, municipal and industrial discharges it is responsible for carrying[10]. The pollution found in that river is entirely man-made, generated either by a dramatic increase in naturally occurring materials or by the release of synthetic compounds (xenobiotics)[11]. Organic and inorganic pollution are the direct result of environmental discharges of domestic, agricultural and industrial wastes[12].

Algae are photosynthetic organisms frequently found in numerous settings, in freshwater and marine areas and in hot springs and frozen ponds. They travel as both small, unicellular forms and as complex, multicellular forms. Certain algae, which play an indispensable part in the self-purification process in water, can flourish in water polluted with organic wastes[13]. Aquatic life is materially affected by the role of algae in the food chain. The algae known to pose the greatest problems in water resources are diatoms, especially Chrysophyta and Euglenophyta, but green algae may also be involved[14].

Bio-indicators can be defined as organisms that provide concrete information about the quality of the immediate environment[15]. Bio-indicators can not only be used to identify and quantify the environmental effects of pollutants but also can inform us about the total ecosystem impact of different pollutants, as well as the likely duration of an identified problem[16]. Many algae are excellent indicators of water quality and the dominant phytoplankton group can be used to characterize and identify many lakes[17]. Nutrient-poor waters allow blue-green algae to survive, while organically polluted waters allow some to thrive[18]. Algae lend themselves well to the study of eutrophication, but also serve as reliable monitors of organic pollution because they have a high, well-documented tolerance of it[19].

Materials and methods

Algal sampling, identification and enumeration: Water samples from Dravyavati River were collected in different seasons (summer, winter and rainy) and stored in sterilized glass bottles. Before sampling, the risk of external contamination was minimized by rinsing these bottles three times with source water. Random samples for the investigation of phytoplankton were collected onsite. Algae were identified and counted microscopically. A 100-ml water sample was collected at each of the selected locations. A 15-ml portion was selected and centrifuged at 3000 rpm at room temperature. The visible content on the concentrated ~20 μl sample was deposited on a glass slide, counted and enumerated under a 40X light microscope. Representative images were taken at 100X magnification. Morphological features – cell character, motility, color, physical and reproductive structures – were used to identify algal species[20].

Heavy metal analysis through atomic absorption spectroscopy: Atomic absorption spectrometry is used to determine low detection limits of an analytical concentration in a sample. Reference standards of a known analytical content are required to establish the relation between the standard and the measured absorption of the unknown. The analytical process works by energetically promoting an electron's orbital state to a higher energy level for a short time (mere nanoseconds). A defined quantity is necessary for this promotion to occur, and the wavelength energy of each element is specific to a particular electron transition. The technique offers elemental selectivity because, generally, each wavelength is associated with only one element, and the width of an absorption line (on the order of a few picometers [pm]), is also characteristic of a particular element. The radiation flux excluding a sample and including a sample in the atomizer is measured by using a detector. The Beer-Lambert Law is used to convert the ratio between the two values (the absorbance) to an analytical concentration[21].

Three different sites (Figure-1, 2, 3) on the Dravyavati River were selected for water sample collection. Good-quality, screw-capped, high-density, pre-sterilized and properly-labeled 1-liter polypropylene bottles were used for collection.

Subsequently, they were analyzed in the laboratory for trace metals by Atomic Absorption Spectrometry (AAS). In order to assess year-round water quality of the river, sampling was carried out during 3 seasons: Summer, Winter and Rainy. Double-distilled water and high purity (Anal R grade) chemicals were used for preparing solutions for analysis.

Standard Methods proposed by the American Public Health Association (APHA) were employed for preservation and analysis of the water samples. The selected heavy metals (As, Cd, Cr, Fe, Mn, Pb and Zn) were analyzed. The detection of trace metals in the environment can be accomplished by various methods but in this study, the AAS technique – which is relatively simple, versatile, accurate and free from interference – was used. Heavy metals readily form complexes with organic constituents; therefore, it is necessary to destroy such complexes by digesting the sample with strong acids. Digestion destroys the organic matter, removes interfering ions and brings metallic compounds in suspension to solution.

Results and discussion

Heavy Metal Analysis of water sample of all 3 sites: Figure-1, 2 and 3 were compiled for heavy metal analysis at sites 1, 2 and 3 in three season - rainy (July-September), winter (November-January), and summer (April-June), all three sites were tested for As, Fe, Mn Zn, Cr, Pb and Cd. In all seasons, some or all of the 3 sites showed the presence of Fe, Mn and Zn, but only Mn at summer site 2 (Figure-3) displayed values above WHO standards.

Microscopic analysis of algal species from all 3 sites: Figure 4, 5 and 6 (again, rainy, winter and summer) all show elevated values for three species of algae at all three sites: Oscillatoria, Navicula and Chorella.

Dravyavati River (Amanishah Nala) was polluted by heavy metal contamination. Many industries discharge their wastes in the Nala. We have found some heavy metal concentrations in Nala water as well as several species of algae. Analysis of heavy metals (Mn, Fe and Zn) has been done by using Atomic absorption spectroscopy. The results show that the water from the area's industrial effluents had a greater heavy metal content (Mn, Fe, and Zn) capable of polluting the environment. These findings imply that the consumption of polluted water by animals or human beings could be hazardous to health. Because the water is contaminated by these effluents, heavy metals can enter the food chain and thus be consumed by human beings.

As confirmation, three species of algae (*Chlorella, Navicula* and *Oscillatoria*) were present in all three seasons tested, and all three are known to be pollution-tolerant, and so indicate that the Nala River water is indeed polluted.

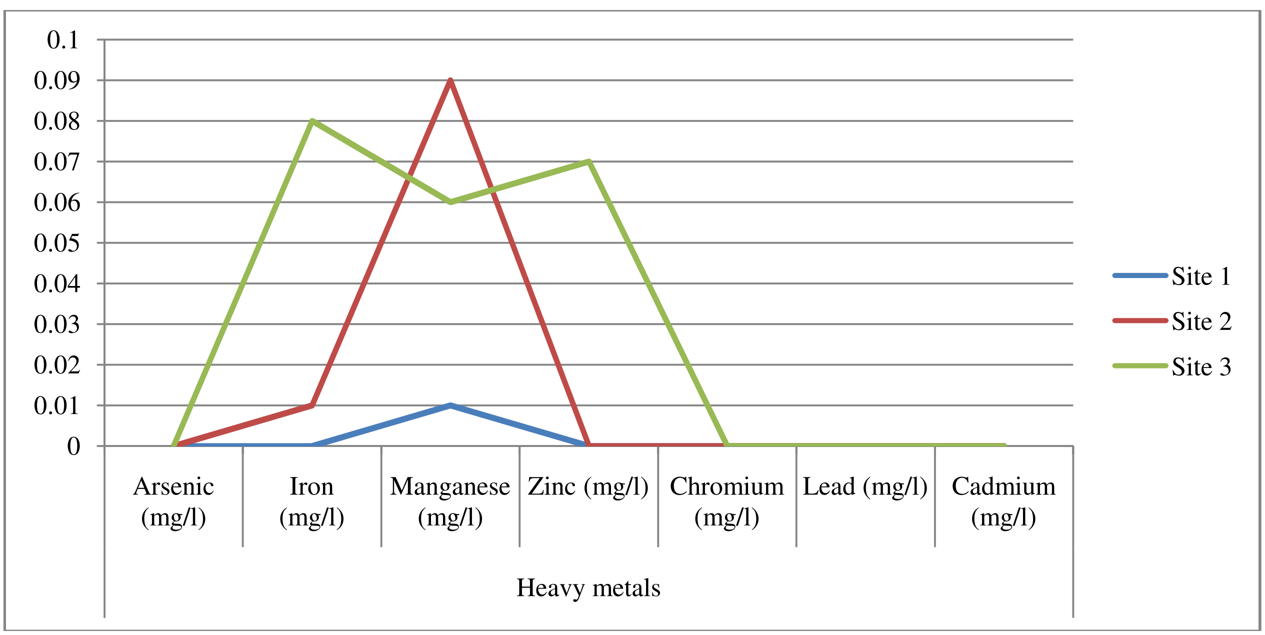

Figure-1: Analysis of Water Samples Collected in Rainy Season (July to September).

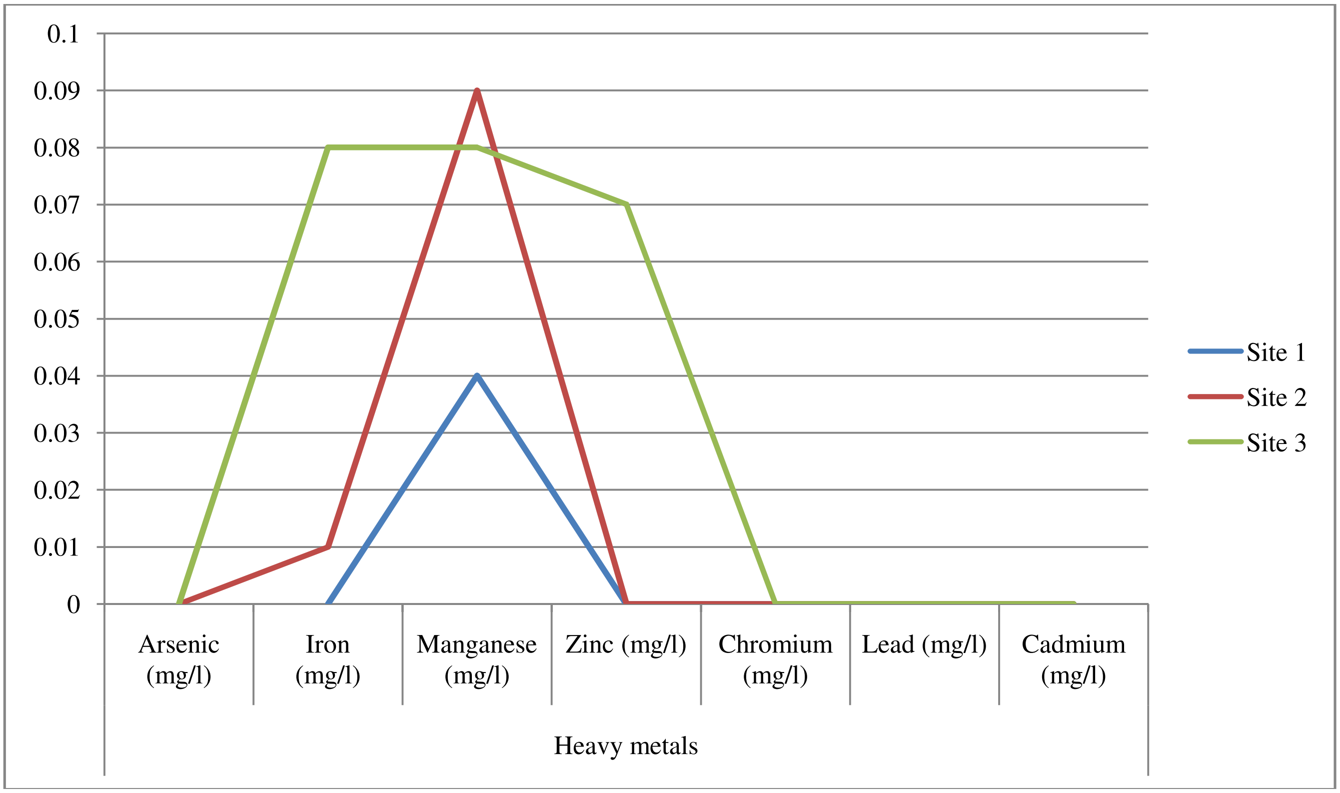

Figure-2: Analysis of Water Sample Collected in Winter Season (November to January).

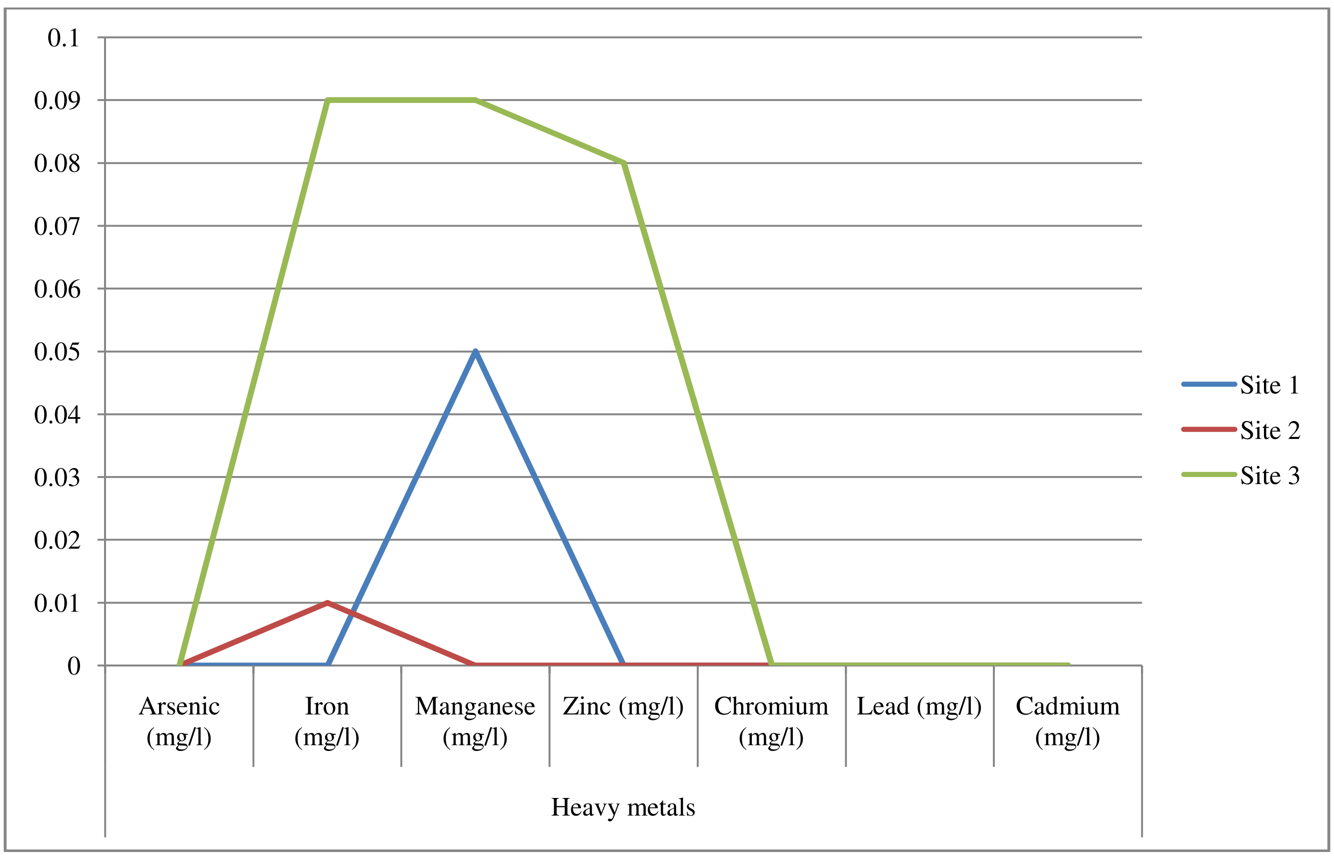

Figure-3: Analysis of Water Sample Collected in Summer Season (April to June).

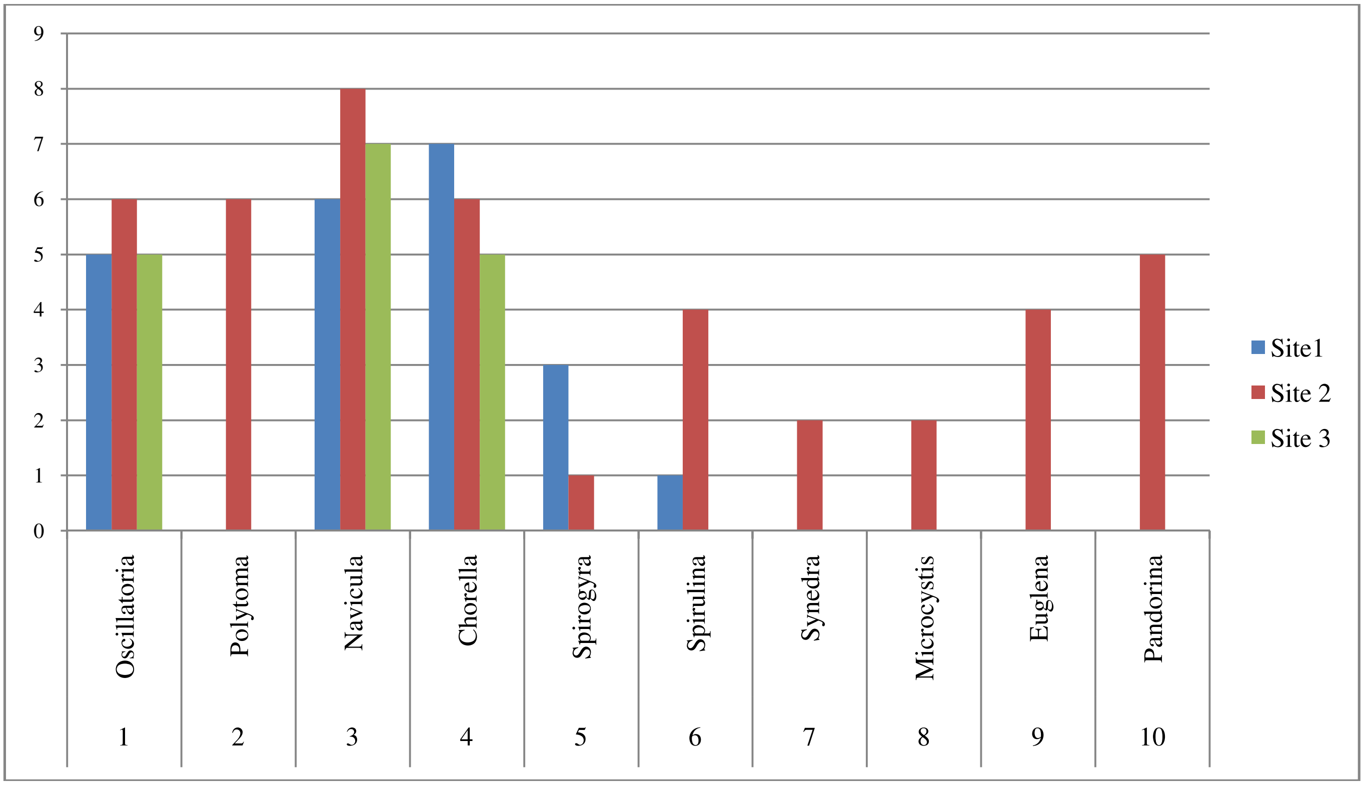

Figure-4: Analysis of Water Samples Collected in Rainy Season (July to September).

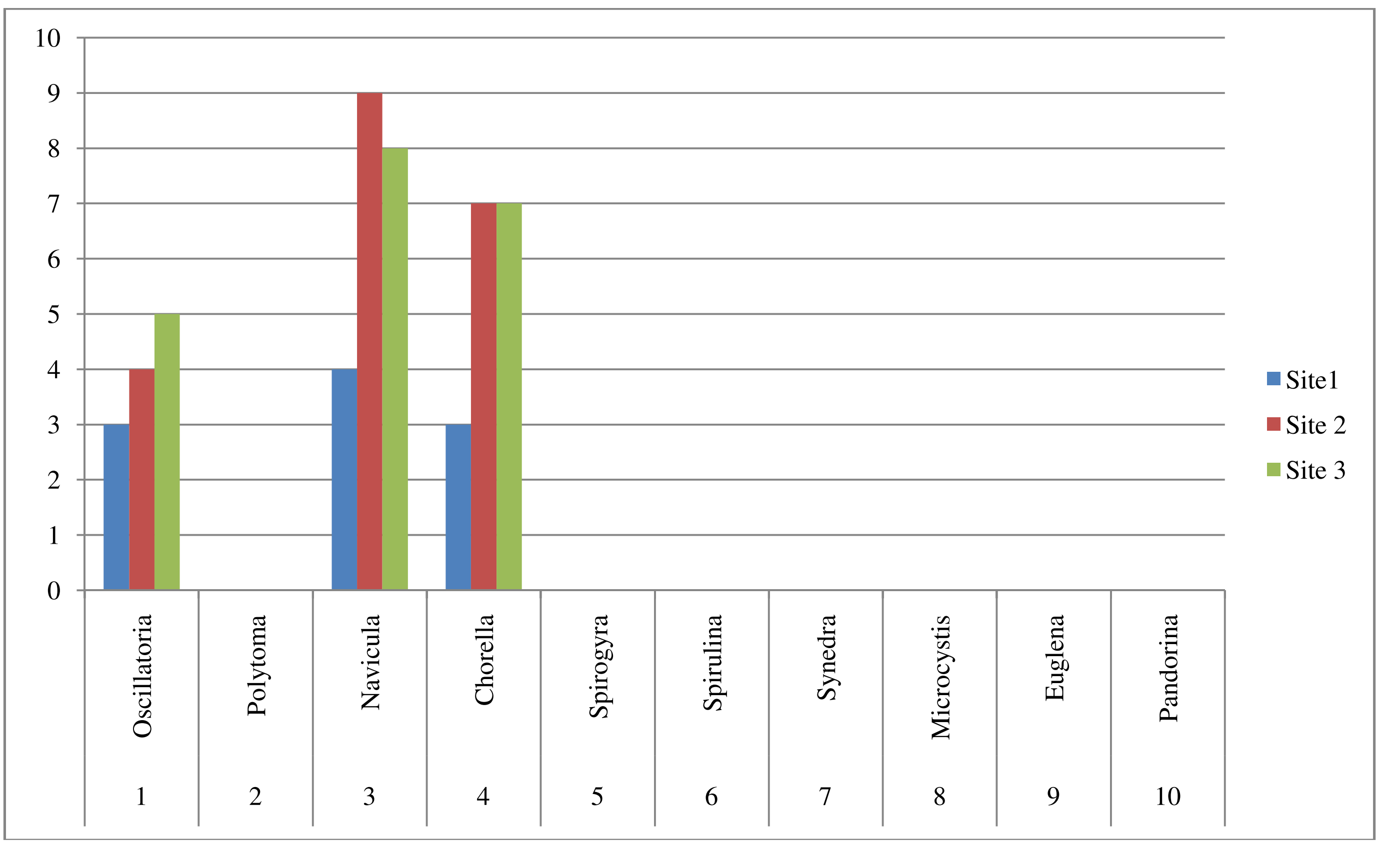

Figure-5: Analysis of Water Sample Collected in Winter Season (November to January).

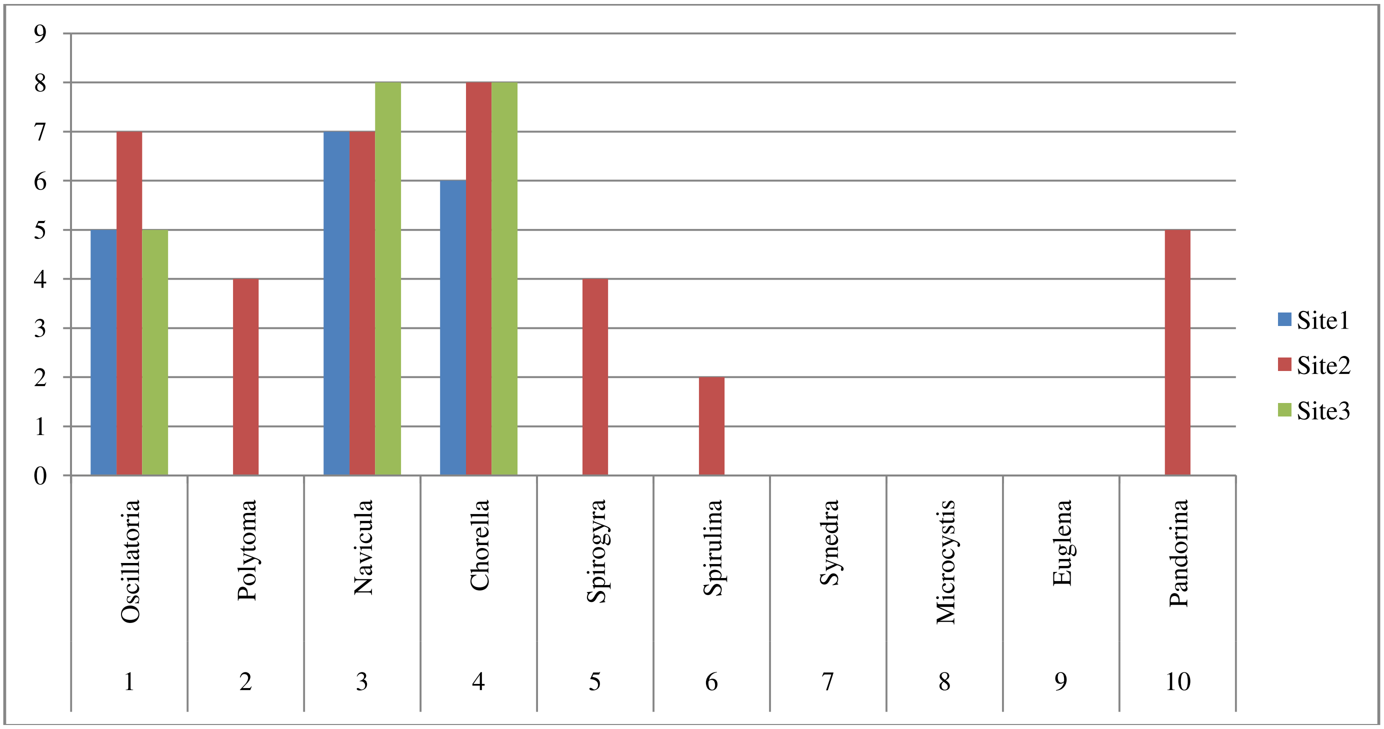

Figure-6: Analysis of Water Sample Collected in Summer Season (April to June).

Significance of study: The Dravyavati River (Amanishah Nala) – "the life line of Jaipur" – is the most polluted waterway in Jaipur. The diversity of the algal population is an indication of the true sanitary and ecological condition of the river. It also indicates its potential for self-purification. We relied on algal bio-indicators to determine pollution levels in the various seasons – rainy, winter and summer – to arrive at an estimate of the self-purification probability of the river system. Commonly used animal indicators of ecosystem health are less useful and unique than bio-indicators provided by algae. The algae allow us to recognize signals in ecosystem changes that identify acceptable – as opposed to unacceptable – environmental situations. In addition, algae are the most cost-effective monitoring tool in our arsenal.

Conclusion

The fact that algae are so quick to respond predictably to the impact of pollutants make them ideal as an early warning system, allowing us to zero in on deteriorating conditions and identify their causes. The nutritional preferences of algae at the base of the food chain provide more relevant and useful information than conventional animal indicators. Ecologic signals provided by algae allow rapid differentiation of acceptable vs. unacceptable ecosystem changes. The algae themselves are extremely cost-effective bio-indicators, and the N:P ratio is a good predictor of which algal community will predominate locally. Algae, because of their high tolerance of heavy metals, are ideal candidates for their selective removal and concentration.

References

1. Hammitt W.E., Cole D.N. and Monz C.A. (2015). Wildl and recreation: ecology and management. 3rd ed. John Wiley and Sons, 1-125. ISBN: 978-1-118-39700-8.
2. Bhatnagar A. (2015). Assessment of Physico-Chemical Characteristics of Paper Industry Effluents. *Rasayan Journal of Chemistry*, 8(1), 143-145.
3. Lindqvist O., Johansson K., Bringmark L., Timm B., Aastrup M., Andersson A., Hovsenius G., Håkanson L., Iverfeldt Å. and Meili M. (1991). Mercury in the Swedish environment—recent research on causes, consequences and corrective methods. *Journals of Water, Air, and Soil Pollution*, 55(2), 261-267.
4. Xu S. and Nirmalakhandan N. (1998). Use of QSAR models in predicting joint effects in multicomponent mixtures of organic chemicals. *Journals of Water Research*, 32(8), 2391-2399. https://doi.org/10.1016/S0043-1354(98)00006-2.
5. Parker I.M., Simberloff D., Lonsdale W.M., Goodell K., Wonham M., Kareiva P.M., Williamson M.H., Von Holle B.M.P.B., Moyle P.B., Byers J.E. and Goldwasser L. (1999). Impact: toward a framework for understanding the ecological effects of invaders. *Journals of Biological Invasions*, 1(1), 3-19.
6. Camargo J.A. and Alonso A. (2006). Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: a global assessment. *Journals of*

Environment International, 32(6), 831-849. https://doi.org/10.1016/j.envint.2006.05.002.

7. Singh J., Yadav H. and Smarandache F. (2009). District Level Analysis of Urbanization from Rural-to-Urban Migration in the Rajasthan State. *Smarandache National Journals*, 1(2), 1-12.

8. Quatrochi P.M. (1995). Groundwater jurisdiction under the Clean Water Act: the tributary groundwater dilemma. *Journals of Boston College Environmental Affairs Law Review*, 23(3), 603.

9. Tiyasha Shaktibala and Bhagat K.S. (2012). Characterization of Waste Water of Industrial area of Sitapura, Jaipur for Post Monsoon Season. *International Journal of Scientific Research and Reviews*, 2, 227-235.

10. Rajput R.S., Pandey S. and Bhadauria S. (2017). Status of water pollution in relation to industrialization in Rajasthan. *Reviews on Environmental Health*, 32(1), 1-8. https://doi.org/10.1515/reveh-2016-0069.

11. Abdel-Raouf N., Al-Homaidan A.A. and Ibraheem I.B.M. (2012). Microalgae and wastewater treatment. *Saudi Journal of Biological Sciences*, 19(3), 257-275. https://doi.org/10.1016/j.sjbs.2012.04.005.

12. Lim S.L., Chu W.L. and Phang S.M. (2010). Use of Chlorella vulgaris for bioremediation of textile wastewater. *Journals of Bioresource Technology*, 101(19), 7314-7322. https://doi.org/10.1016/j.biortech.2010.04.092.

13. Sen B., Sonmez F., Kocer M.A.T., Alp M.T. and Canpolat O. (2013). Relationship of algae to water pollution and waste water treatment. *Intech Open Access Publisher*, DOI: 10.5772/51927.

14. Silvey J.K.G. and Roach A.W. (1959). Laboratory Culture of Taste and Odor Producing Aquatic Actinomycetes. *Journal American Water Works Association*, 51(1), 20-32.

15. Markert B.A., Breure A.M. and Zechmeister H.G. (2003). Bioindicators and biomonitors. 6 Gulf Professional Publishing, 1-1041.ISBN: 9780080441771.

16. Rajput R.S. and Pandey Bhadauria (2016). Correlation of Biodiversity of Algal Genera with Special Reference to the Waste Water Effluents from Industries. *American journal of Engineering and Applied Science Engineering and Applied*, 9(4), 1127-1133. DOI:10.3844/ajeassp.2016.1127.1133.

17. Brook A.J. (1965). Planktonic algae as indicators of lake types, with special reference to the Desmidiaceae. *Limnology and Oceanography*, 10(3), 403-411. DOI: 10.4319/lo.1965.10.3.0403.

18. Paswan G., Prakash S. and Nikhil K. (2014). Biofuel as Green Energy Source: A. *International Journal of Engineering and Technical Research*, 2(3), 124-126.

19. Palmer C.M. (1969). A Composite Rating of Algae Tolerating Organic Pollution. *Journal of Phycology*, 5(1), 78-82. DOI: 10.1111/j.1529-8817.1969.tb02581.x.

20. Prescott G.W. (1956). A guide to the literature on ecology and life histories of the algae. *The Botanical Review,* 22 (3), 167-240.

21. Dakashev A.D., Pavlov S.V. and Stancheva K.A. (2012). Flame atomic absorption spectrometry based on self-absorption in the flame and using the flame as a light emission source. *Advances in Analytical Chemistry*, 2(4), 37-40. doi: 10.5923/j.aac.20120204.03.