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Review Article

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Biological indicators to check water quality in plastic-heavy water bodies

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ABSTRACT

Water quality is a canonical group of physical, chemical, and biological properties of the given water. The environment and its compartments have been severely polluted by heavy metals and plastic waste. This has compromised the ability of the environment to foster life and render its intrinsic values. Human population increase and consistent demand for heavy metals and plastic products are responsible for continuous increase in the production of plastic and heavy waste and its accompanied environmental pollution. Biological indicators help in indicating and monitoring the health of the environment. Here, an overview on recent achievements in checking water quality and water pollution trends has been summarized. Papers that reported environmental and public health effects related to plastic-heavy pollutants have also been reviewed. The research for this article intends to further facilitate the R&D initiatives of Jozbiz Technologies Pvt. Ltd.

KEYWORDS: Bioindicator; Plastic; Water quality; Environment

INTRODUCTION

Human activities have severely affected the condition of freshwater ecosystems worldwide. Physical alteration, habitat loss, water withdrawal, pollution, overexploitation and the introduction of non-native species all contribute to the decline in freshwater species and the water quality as well. Increasing human population growth and achieving sustainable development targets place even higher demand on the already stressed freshwater ecosystems. Water quality is a measurement to determine the pollution level that happens in water, showing the reaction in water composition towards all the input whether is natural or manmade. However, physical and chemical monitoring instruments are usually expensive and can only be used at limited number of sites thus unable to achieve distribution patterns. Hence, biological monitoring is considered one of alternatives which useful and rapid assessment tool to check the status of water quality. Typically, plastics in the oceans can degrade within a year but not completely. During this plastic degradation process, toxic chemicals like polystyrene and BPA can be released into the water causing water pollution. Wastes found in the oceans are made up of approximately 80% plastics [Table 1] (Schmidt *et al.*, 2017). Plastic debris which are floating on the ocean can be rapidly colonized by sea organisms and due to persistence on the ocean surface for a long period of time, this mayaid the movement of 'alien' or non-native species. Contaminants from microplastics are bioavailable for many marine lives because of their presence in benthic and pelagic ecosystems and their small sizes. Within the marine ecosystem, plastics have been reported to concentrate and sorb contaminants present in the seawater from different other sources. Examples of such contaminants are persistent organic pollutants like nonylphenol, PCBs, dichlorodiphenyldichloroethylene (DDE) and phenanthrene, with potential to accumulate in several fold on the plastic debris compared to the surrounding seawater. More than 260 species of marine organisms such as turtles, invertebrates, seabirds, fish and mammals ingested or are entangled in or with plastic debris, leading to reduced movement, feeding, reproductive output, ulcers, lacerations and eventual death [Table 2] (Boyer *et al.*, 2009). Metals, such as cadmium and lead, are often used in manufacturing plastic and over time can enter coastal waters. Once floating in the ocean or discarded on a beach and washed by the tides, plastics can also attract and concentrate a variety of metals already present in the environment that attach themselves, or "sorb," to the surface. In both cases, the worry is that these metals – often toxic ones such as cadmium that are health concerns for both wildlife and humans – can contaminate waters or harm wildlife that ingest plastics, especially those that live in intertidal zones near sources of plastic pollution. A previous study examining metals sorbing onto plastics have found that the age of the material also matters. Chelsea Rochman, an assistant professor at the University of Toronto's department of ecology and evolutionary biology, led a study when she was at San Diego State University in which her team dropped mesh bags of various kinds of plastic pellets into three areas around San Diego Bay in California. They measured how much aluminum, chromium, manganese, iron, cobalt, nickel, zinc, cadmium and lead from the environment sorbed onto their samples. The presence of a toxic metals-saturated biofilm on plastics could be both an ecological and human health problem.

The bacterial growth on the biofilm could potentially pick up pathogens in and around coastal areas. And as these plastics break down into smaller and smaller pieces, they're more easily ingested by marine life, and now it looks like they're bringing dangerous metals along for the ride. While the studies were conducted in North America, the environmental risks may be far greater in regions like Southeast Asia that lack waste management infrastructure and where more plastic pollution makes its way to the coast.

Plastic Pollution Trends

While plastic has many valuable uses, we have become addicted to single-use or disposable plastic — with severe environmental consequences. Around the world, one million plastic drinking bottles are purchased every minute, while 5 trillion single-use plastic bags are used worldwide every year. In total, half of all plastic produced is designed to be used only once — and then thrown away. By the 1990s, plastic waste generation had more than tripled in two decades, following a similar rise in plastic production. In the early 2000s, our output of plastic waste rose more in a single decade than it had in the previous 40 years. Today, we produce about 300 million tonnes of plastic waste every year. Researchers estimate that more than 8.3 billion tonnes of plastic has been produced since the early 1950s.

We're seeing some other worrying trends. Since the 1950s, the rate of plastic production has grown faster than that of any other material. We've also seen a shift away from the production of durable plastic, and towards plastics that are meant to be thrown away after a single use. More than 99% of plastics are produced from chemicals derived from oil, natural gas and coal — all of which are dirty, non-renewable resources. If current trends continue, by 2050 the plastic industry could account for 20% of the world's total oil consumption. These single-use plastic products are everywhere. For many of us, they've become integral to our daily lives. Like Polyethylene terephthalate (PET), High—density polyethylene (HDPE), Low—density polyethylene (LDPE), Polypropylene (PP), Polystyrene (PS), Expanded polystyrene (EPS). We need to slow the flow of plastic at its source, but we also need to improve the way we manage our plastic waste. Because, right now a lot of it ends up in the environment.

Only 9% of all plastic waste ever produced has been recycled. About 12% has been incinerated, while the rest — 79% — has accumulated in landfills, dumps or the natural environment (Jambeck *et al.*, 2015). Rivers carry plastic waste from deep inland to the sea, making them major contributors to ocean pollution [Figures 1 and 2]. A staggering 8 million tonnes of plastic end up in the world's oceans every year. How does it get there? A lot of it comes from the world's rivers, which serve as direct conduits of trash from the world's cities to the marine environment. Plastic waste — whether in a river, an ocean, or on land — can persist in the environment for centuries.

China's Chang Jiang (Yangtze) River, which flows past Shanghai, delivers nearly 1.5 million tons of plastic waste into the Yellow Sea.

The same properties that make plastics so useful — their durability and resistance to degradation — also make them nearly impossible for nature to completely break down. Most plastic items never fully disappear; they just get smaller and smaller. Many of these tiny plastic particles are swallowed by farm animals or fish who mistake them for food, and thus can find their way onto our dinner plates. They've also been found in a majority of the world's tap water (Hoornweg *et al.*, 2013). By clogging sewers and providing breeding grounds for mosquitoes and pests, plastic waste — especially plastic bags — can increase the transmission of vector-borne diseases like malaria.

Heavy Metal Trends

Heavy metals are one of the most widespread causes of pollution both in water and the soil. Further, increasing levels of these metals concentration in the environment is causing serious concern in public opinion owing to the toxicity shown by most of them. Heavy metals are usually defined as metals with high atomic number, atomic weight and a density greater than 5.0 g/cm^3. Generally speaking, metals are natural components of the Earth's crust and some of them (e.g. copper, selenium, and zinc) are essential as trace elements to maintain the metabolism of the human body although at higher concentrations, they may show toxic effects (Wilson, 2015). Many other metals (e.g. mercury, cadmium, lead, etc.) have direct toxic effects on human health. These pollutants enter the environment through a variety of human activities such as mining, refining and electroplating industries (Barnes *et al.*, 2019). Even if they may be present in dilute, almost undetectable quantities, their recalcitrance to degradation and consequent persistence in water bodies imply that, through natural processes such as bio-magnification, their concentration may become elevated to such an extent that they begin exhibiting toxic effects. Large amounts of any of these metals may cause acute or chronic toxicity (poisoning), resulting in damaged or reduced mental and central nervous functions, modify blood composition, damage the lung, kidney, liver, and other vital organs. Long-term exposure to the above-mentioned heavy metals may result in slowly progressing physical, muscular, and neurological degenerative processes. Although several adverse health effects of heavy metals have been known since a long time, exposure to these metals is continuing and even increasing in some parts of the world. Thus, the control of heavy metal dumplings and the removal of toxic heavy metals from waters has become a challenge for the twenty-first century (Wagner *et al.*, 2014).

Ganga River: The Ganga is the 20th longest river in the Asia and the 41st longest in the world (Source: Philips World Atlas). The headwaters region of Ganga is the Himalayas dotted by number of mighty tributaries. The total length of river Ganga (measured along the Bhagirathi and the Hooghly) up to its outfall into Bay of Bengal is 2,525 km with 631 km navigable length. Ganga has been a cradle of human civilization since time immemorial. Millions depend on this great River for physical and spiritual sustenance (Rillig, 2012). It is a life-line, a symbol of purity and virtue for countless people of India. But due to rapid industrialization, increase in urban population, change in lifestyle, use of artificial fertilizer has led to deterioration in water quality of holy river. At certain stretches the river water is grossly polluted mostly due to industrial and municipal sewage discharge in the river Ganga. There are 18 water quality stations at Deoprayag, Rishikesh, Haridwar, Garhmukteshwar, Kachlabridge, Fatehgarh, Ankinghat, Kanpur, Bhitaura, Shahzadpur, Chhatnag Allahabad, Mirzapur, Varanasi, Buxar, Gandhighat (Patna), Hathidah, Azamabad and Farakka on the main stream of the river Ganga.

Oservations/Findings: From the above graphs it is observed that, during the study period in monsoon and non-monsoon seasons almost all the parameters concentration observed below the threshold value except iron from Kanpur to Azmabad stretch during monsoon (Dris *et al.*, 2016). During the study period, all the Ganga River water quality stations data reported that arsenic and zinc concentration lies within the acceptable limits of Bureau of Indian Standards (BIS) and no toxicity of arsenic and zinc in the River waters is observed. The concentration of the cadmium, chromium, lead and iron varies in the Ganga River are 0.001-3.936 μg/L; 0.080-205.82 μg/L; 0.020-36.91 μg/L and 0.002-1.53 mg/L respectively Page | 81 Status of Trace & Toxic Metals in Indian Rivers 2019 during the May, 2014 and April, 2018. Generally elementary iron dissolves in water under normal conditions.The iron concentration in the River Ganga was vaired between 0.002-1.53 mg/L (Plastics Europe, 2006).

Chlorophyll a as a Bio-Indicator

Chlorophyll a is a measure of the amount of algae growing in a water body. It can be used to classify the trophic condition of a water body. Although algae are a natural part of freshwater ecosystems, too much algae can cause aesthetic problems such as green scums and bad odors, and can result in decreased levels of dissolved oxygen. Some algae also produce toxins that can be of public health concern when they are found in high concentrations. One of the symptoms of degraded water quality condition is the increase of algae biomass as measured by the concentration of chlorophyll a. Waters with high levels of nutrients from fertilizers, septic systems, sewage treatment plants and urban runoff may have high concentrations of chlorophyll a and excess amounts of algae. Inflow of polluted water in the bay is altering the structure and function of this estuary. There is generally a good agreement between planktonic primary production and algal biomass, and algal biomass is an excellent trophic state indicator. Furthermore, algal biomass is associated with the visible symptoms of eutrophication, and it is usually the cause of the practical problems resulting from eutrophication (Plastemart, 2005). Phytoplankton blooms are a major concern in the Florida bay and nershores of the Florida coast (Cooper *et al.*, 2014). Phytoplankton bloom s causes deficiency in light penetration which caused depressed and retarded growth of seagrass and its productivity. Decomposition of seagrass leads to release of nutrients in the environment and stimulates more phytoplankton growth (Rochman *et al.*, 2016). A restoration plan was created CERP (Comprehensive Everglades Restoration Plan). It provides a framework and guide to restore, protect and preserve the water resources of central and southern Florida, including the Everglades. In this plan various parameters were set for external and internal nutrient cycle, light availability, water residue time etc. CERP implementation will affect dissolved and particulate nutrients delivered to the estuaries and alter estuarine water quality. Furthermore, the amount of nitrogen flowing into the bay from this source appears to increase with increasing freshwater flow. It is not certain that the quality of this nitrogen (its "bioavailability"), which is contained in dissolved organic compounds, is sufficient to fuel phytoplankton blooms (Zhan-feng & Bing, 2009). Phytoplankton blooms have been observed to cover large areas of the central and western bay for extended periods of time (especially during summer and fall). Phytoplankton blooms may have diminished ecosystem integrity and the abundance and sustainability of living marine resources (e.g. fish and shrimp) that depend on seagrass habitat. Assessing phytoplankton bloom condition is essential to ensure that water quality in the southern estuaries is not degraded by CERP implementation and a highly oligotrophic system transformed into a eutrophic ecosystem with decreased sea grass cover and diminished extent of the high quality benthic nursery habitat necessary to support commercial and recreational fisheries.

Phytoplankton blooms are generally known to be sensitive to nutrient inputs and the southern estuaries are no exception. In fact, the recent, dramatic phytoplankton bloom in the sounds of northeast Florida Bay and southern Biscayne Bay highlighted the sensitivity of this module to an increase in ambient TP concentrations (from approximately 0.01 ppm to 0.10 ppm), likely from Everglades, Florida Bay, and Florid Bay sources that were disturbed by hurricanes and human activities (Hoornweg & Bhada-Tata, 2012). The bloom was initiated and chlorophyll a increased eight-fold in response to this increase in TP concentration. CHLA responds to both macronutrient loading and availability and is thus a more sensitive and relevant indicator of water quality than nutrient concentrations per se. In addition to nutrients, this indicator integrates the effect of grazers both benthic and pelagic as well changes in turbidity associated with sediment resuspension and light extinction from turbidity and phytoplankton, which influence the sustainability of SAV habitat (China Ministry of Commerce, 2016).

Use of bio-indicator for the restoration of America's Everglades helped to avoid the deterioration of the fauna and flora life in the Florida Bay and its coast.

The main goals achieved are:

- Improved water quality, water supply and wildlife habitat while maintaining flood protection;
- Reduced excess freshwater releases to coastal estuaries; and
- Improved water delivery to Biscayne and Florida bays.

Table 1: Plastic loads for the top 10 rivers (Schmidt *et al.,* 2017)

Chang Jiang (Yangtze River)	1,469,481 tons
Indus	164,332 tons
Huang He	124,249 tons
Hai He	91, 858 tons
Nile	84, 792 tons
Megha, Brahmaputra, Ganges	72, 845 tons
Zhujiang (Pearl River)	52, 958 tons
Amur	38,267 tons
Niger	35,196 tons
Mekong	33,431 tons

Table 2: List of distinct water quality zones in Florida Bay and Biscayne Bay and their associated algal bloom thresholds as CHLA (ppb). (Boyer *et al.,* 2009)

Sub-region	Zone	Valid N	25th percentile	Median	75th percentile
Blackwater, Manatee	BMB	1704	0.306	0.526	0.910
Central Biscayne Bay	CBB	1673	0.200	0.313	0.566
Mangrove Transition Zone	MTZ	3803	1.690	2.863	4.903
North Biscayne Bay	NBB	635	0.670	1.048	1.648
North-Central Florida Bay	NCFB	1399	0.585	1216	3.710
Northeast Florida Bay	NCFB	1979	0.254	0.417	0.790
South Biscayne Bay	SBB	2257	0.818	0.264	0.426
South Florida Bay	SFB	1695	0.327	0.533	1.059

Table 3: The most common permissible limits of heavy metals in aquatic environments for fish health

Heavy Metal	Freshwater (ug/L)	Seawater (ug/L)
Lead	0.18-1.00	0.02-0.05
Mercury	0.02	0.02
Cadmium	0.05	1
Chromium	5	5
Copper	0.1	2
Nickel	0.1	2

Marine Organisms as Bio-Indicators

The ever-increasing level of marine pollution due to plastic debris is a globally recognized threat that needs effective actions of control and mitigation. Using marine organisms as bioindicators of plastic pollution can provide crucial information that would better integrate the spatial and temporal presence of plastic debris in the sea. Given their long and frequent migrations, numerous marine species that ingest plastics can provide information on the presence of plastic debris but only on large spatial and temporal scales, thus making it difficult to identify quantitative correlations of ingested plastics within well-defined spatio-temporal patterns. Given the complex dynamics of plastics in the sea, the biomonitoring of marine plastic debris should rely on the combination of several bioindicator species with different characteristics that complement each other [Figures 3 and 4] (U.S. Environmental Protection Agency, 2013).

Numerous species of different taxonomic groups have been used as bioindicators (Haggard *et al.*, 2013) of diverse marine pollutants such as: mollusks (Rudnick *et al.*, 2005), turtles, fish, sponges for heavy metals; polychaetes and mollusks for pharmaceuticals; fish and mollusks for organic pollutants [Table 3]. Seabirds are the most studied group of species used as bioindicators of marine plastic debris. The majority of studies investigated northern fulmars (Boyer & Keller, 2007), while other publications included albatrosses, auklets, cormorants and kittiwakes. Sea turtles are another group of widely investigated marine species, with most articles focusing on loggerhead sea turtles (Fourqurean & Robblee, 1999), followed by green sea turtles (Boyer & Briceño, 2006). A third group of quite investigated species, but mainly in laboratory experiments, included mussels, in particular the blue mussel (Childers *et al.*, 2006) and the Mediterranean mussel. Other investigated taxonomic groups included fish, mammals, polychaetes, bryozoans, holothurians, and also bacterial communities. Several studies, in particular, investigated the harmful effects of ingested plastics in single species (Cesar-Ribeiro *et al.*, 2017). The selection of bioindicator species follows general criteria that can be applied also to plastics in the sea, therefore many more species than those so far investigated could act as potential bioindicators of marine plastics. In particular, given the pervasive nature of marine plastics, cosmopolitan species should be considered as primary sentinels of environmental impact because greater ecological niche allows organisms to detect the same disturbances or stressors in different habitats (D'Costa *et al.*, 2017). Wide distribution is, indeed, a prominent aspect for candidate bioindicator species because it is based on the rationale that organisms with a widespread geographical presence allow to: set large-scale monitoring networks, facilitate multi-scale comparisons between different territories, and carry out meta-analysis studies. Several scholars, in particular, showed that northern fulmars (*F. glacialis*) act as suitable bioindicators of trends in marine plastic pollution because, like many petrels, fulmars forage exclusively at sea and are prone to ingest anthropogenic debris because of their non-selective feeding at the sea surface (Viñas *et al.*, 2018). This suggests that beached northern fulmars are ideal biomonitors for plastic pollution in coastal areas, where they are prone to being washed up on beaches in sufficient numbers. Together with their high abundance and wide distribution, all these features make fulmars promising candidates for the ecological monitoring of plastic litter in the marine environment. Moreover, the content of debris in the stomach of northern fulmars is used as an indicator of regional plastic pollution, by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR convention). This indicator, called "EcoQO" and standing for "Ecological Quality Objectives for the North Sea", states that acceptable ecological conditions are defined as "less than 10% of northern fulmars having 0.1 g or more plastic in the stomach in samples of 50–100 beached fulmars, from each of 5 different regions of the North Sea, over a period of at least 5 years" (OSPAR convention). However, fulmars could act as good bioindicators only for monitoring on large geographical and temporal scales. Indeed, the migratory capacity of fulmars allow them to travel across much or all of the North Sea in a single or very few days, thus implying that local differences of plastic pollution within the North Sea are unlikely to be clearly reflected in their stomach (Donnelly-Greenan *et al.*, 2014).

The loggerhead sea turtle (*C. caretta*) is used worldwide as a pollution bioindicator, and is considered as a flagship species that is included in the main actions of many conservationist organizations, since it helps to increase public awareness about the health of our seas. Loggerheads are the most abundant chelonians in the Mediterranean sea (Hoarau *et al.*, 2014), they feed at sea and can inhabit different habitats in oceanic and neritic zones during their lifetime (Fraga *et al.*, 2018). Since adult individuals search for food from the sea bottom up to the whole water column, they are prone to ingest plastic debris from numerous habitats, whereas juvenile turtles prefer to feed at the sea surface. In particular, found a very high amount of plastic debris in the feces of by-caught rehabilitated sea turtles, and showed that most of loggerheads, which defecated plastic debris, survived, thus resulting in a relative tolerance to plastic ingestion. However, several factors may also bias the amount of plastics ingested by loggerheads. Previous studies found a decreasing trend of ingestion with increasing age, especially older coastal benthic-feeding turtles seem less prone to ingest plastic litter than young oceanic turtles (Farrell & Nelson, 2013). Developmental stage and size of samples can also influence the quantity of ingested plastics, since marine litter can be mistaken for food, more or less easily, according to the complex life stages of loggerheads. The European Commission issued the MSFD, that aims to maintain or achieve the Good Environmental Status (GES) of the sea, and the loggerhead sea turtle was in many EU Member States selected for monitoring the quantity and composition of litter ingested by marine animals. Moreover, the experts of the Technical Subgroup on Marine Litter, nominated by the Member States, recognized sea turtles as target species for the monitoring of litter (including plastics) ingested by organisms in the Mediterranean Sea (von Moos *et al.*, 2012).

The blue mussel (*M. edulis*) and the Mediterranean mussel (*M. galloprovincialis*) are two well-known bioindicators of marine pollution, more and more employed for monitoring the presence of plastic debris (Bartell, 2006). Mussels are filter-feeders that ingest also microplastics, which can be

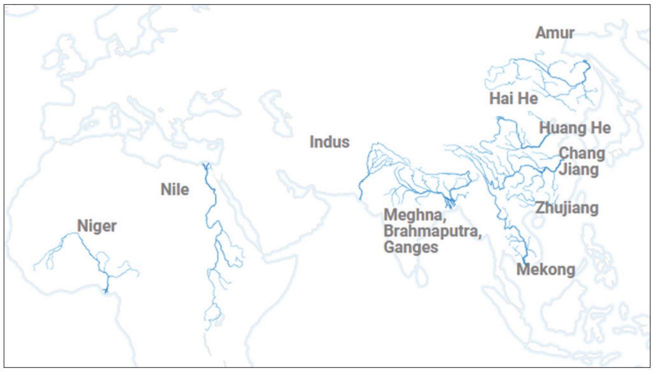

Figure 1: These 10 rivers alone carry more than 90% of the plastic waste that ends up in the oceans

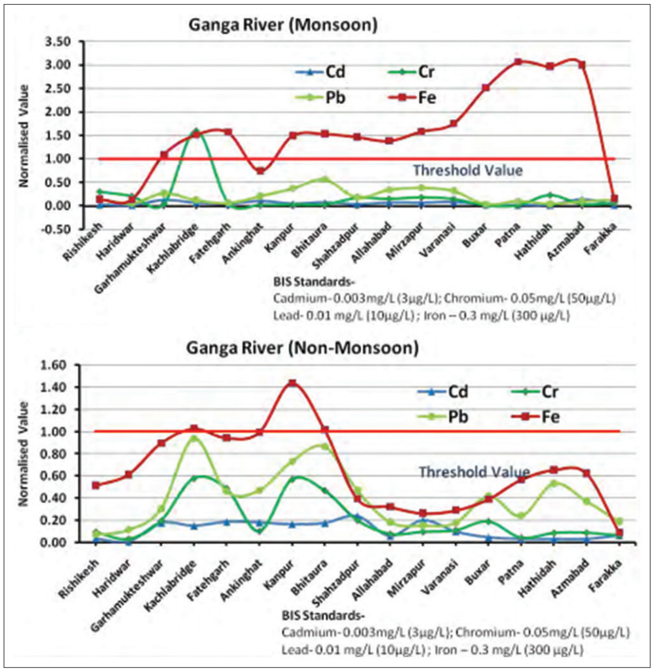

Figure 2: Source: Ministry of Jal Shakti Dept. of Water Resources, River Development and Ganga Rejuvenation Central Water Commission August, 2019

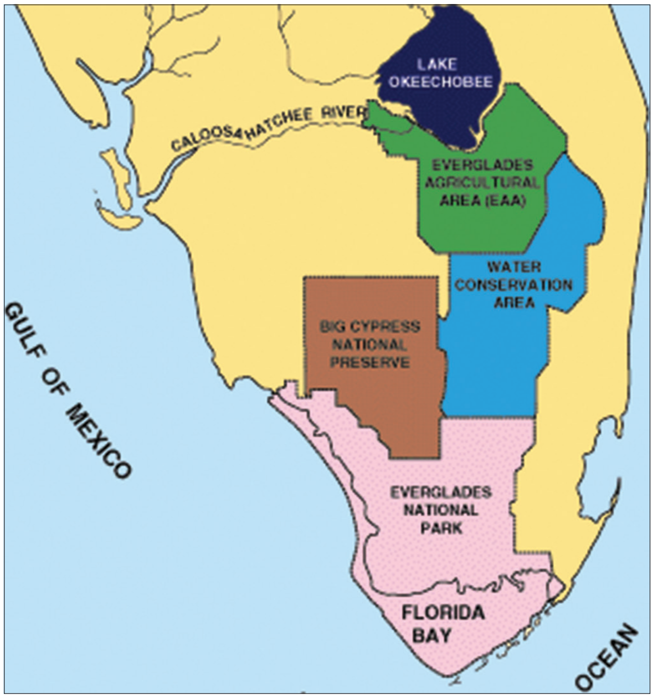

Figure 3: Source: Florida Dept of Environmental Protection

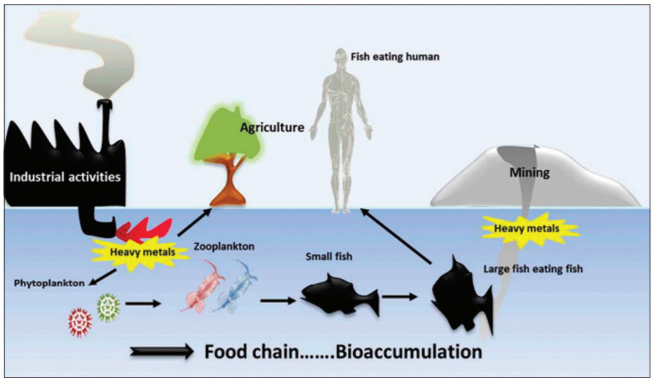

Figure 4: Source: Multidisciplinary Digital Publishing Institute

accumulated from 0.20–0.40 particles/g of soft tissues up to 500 times greater concentrations. Although the short-term exposure to microplastics may not result in significant biological effects (Kühn & van Franekeer, 2012), its ingestion by mussels has shown to determine disruptive effects such as reduction of filtering activity (van Franeker & Law, 2015), changes in a tissue-dependent manner at the transcriptome level, histological changes, and strong inflammatory response. Similarly to loggerhead sea turtles, blue and Mediterranean mussels have a global geographical distribution and have also the great advantage of being sessile organisms. Indeed, stationary bioindicator species (e.g. rooted plants) can provide historical information regarding past environmental conditions, and are a cost-effective approach for monitoring long-term impacts compared to water and sediment, whose contamination patterns require periodic analyses to be identified. While sea turtles are nektonic species acting mainly as qualitative bioindicators of plastics (giving information on absence/presence and type of plastic debris), mussels are instead sessile benthic organisms that may act as quantitative indicators, allowing the development of robust correlations between well-defined geographical locations, magnitude intensity and exposure time to plastic pollution. Overall, fulmars, loggerheads and mussels should be jointly used for integrated biomonitoring, where multiple bioindicator species have different characteristics that complement each other.

Bio-Indicators to Check Heavy Metal

As a result of the global industrial revolution, contamination of the ecosystem by heavy metals has given rise to one of the most important ecological and organismic problems, particularly human, early developmental stages of fish and animal life. The bioaccumulation of heavy metals in fish tissues can be influenced by several factors, including metal concentration, exposure time, method of metal ingestion and environmental conditions, such as water temperature. Upon recognizing the danger of contamination from heavy metals and the effects on the ecosystem that support life on earth, new ways of monitoring and controlling this pollution, besides the practical ones, had to be found. Diverse living organisms, such as insects, fish, planktons, livestock and bacteria can be used as bioindicators for monitoring the health of the natural ecosystem of the environment. Parasites have attracted intense interest from parasitic ecologists, because of the variety of different ways in which they respond to human activity contamination as prospective indices of environmental quality. In this aspect, macrophytes, phytoplankton, invertebrates, and fish are widely used as bioindicators for heavy metals pollution (Casale *et al.*, 2008). Fish parasites are considered very sensitive to heavy metal pollution, as they not only accumulate toxicants in their tissues, but they also exert a physiological response to it (Bolten & Witherington, 2003). Parasites can be used either as effect indicators or as accumulation indicators, because of the variety of ways in which they respond to anthropogenic pollution. Accumulation indicators are organisms that can concentrate certain substances in their tissues to levels significantly higher than those in the ambient. So, intestinal helminths parasites affecting fish can be used in the biomonitoring of heavy metal pollution in the aquatic environment (Casale & Marco, 2017). Indeed, intestinal parasites of fish as acanthocephalans are thorny-headed worms that can accumulate higher concentrations levels of heavy metals than those accumulated in the host tissues (MSFD-TS Marine Litter, 2013). In this aspect, helminths parasites, especially intestinal ones (trematodes, nematodes, cestodes, and acanthocephalans) are used as biological indicators for heavy metal pollution in the aquatic environment. The main threats for fish consumers are associated with exposure to cadmium, mercury, arsenic, and lead (Avio *et al.*, 2015). For human beings, there are several different sources of heavy metal pollution such as rechargeable nickel-cadmium batteries and cigarette smoking, which is considered as the major source for cadmium exposure, inducing serious effects such as renal damage and bone fracture. However, humans could be exposed to mercury through food, fish and using or breaking products containing mercury (Browne *et al.*, 2008). Although there are many sources for heavy metal contamination, they finally reached the fish, causing dangerous effects on fish as well as fish consumers. These exposure sources are usually increased due to the development of human activities, increased industrialization, and waste discharge into the fish environments (Besseling *et al.*, 2013). The most famous types of heavy metal causing pollution for fish are mercury, copper, cadmium, lead, zinc, chromium, manganese, and iron.

The absorption and accumulation of different types of heavy metals are representing a big hazardous for the fish ecosystem. The accumulation of heavy metals in fish tissues is influenced by several extrinsic factors such as metal concentration, exposure period, way of metal uptake, and environmental parameters as water temperature; or intrinsic factors such as size and age. In general, the ability of heavy metals to bioaccumulate and biomagnifying and difficulty to be eliminated from the body by the ordinary metabolic activities makes them one of the most dangerous sources of chemical water pollution to fish, causing big losses to fish and effects on the fish consumers (Vardanyan *et al.*, 2007).

The bioaccumulation of heavy metals due to mining and industrial activities, and its effect on the aquatic food chain. Recently, fish-parasite-heavy metals are considered as an effective monitoring system to evaluate the quality of the environmental fish ecosystem, where the parasites can indicate different pollutants in fish environments, such as heavy metals and sewage pollution. Herein, fish parasites could be used as a biological indicator, to illustrate the ecology of the infected hosts including migration, feeding, and population culture. Several classes of parasites such as Monogenea, Rhabditophora, Cestodes, or Hexanauplia could infect the freshwater or marine water fish. Infected fish tissues revealed severe histologic cellular responses, with different degrees of severity correlated with the severity of the parasitic infestation. The presence of the bile acids in the lumen of fish resulted in the formation of organic-metallic complexes, which are easily absorbed by the worms due to lipophilicity (Diamant, 1989). Malek *et al.* (2007) concluded that the concentration of lead and cadmium in Cestoda "Paraotigmatobothrium spp. and Anthrobothrium spp." were higher than their levels in liver, kidneys, and gonads of shark collected from Iranian coastal water (Sures *et al.*, 2017). This finding has strongly supported the theory that the helminths parasites are extremely sensitive bioindicators that may serve as an early warning, particularly in the sensitive low-level environmental threats. By using parasitism and heavy metals as a bioindicator for pollution of the fish ecosystem, we can detect the health status of the fish environment. Additionally, we found that the parasitism had an environmental impact and demonstrated that parasites are important for biodiversity and development, as well as a healthy system which is rich in a diverse parasite fauna. Consequently, the parasite might be used as a good biological indicator for the environmental quality of the ecosystem.

Plastic Waste Treatment tn India

According to Central Pollution Control Board report the calorific value of plastic wastes can be utilized effectively by replacing coal. The use of plastic waste as alternative fuel will help to reduce the energy cost along with reduction in the CO_2 emissions. During co-incineration of plastic waste in blast furnace and cement kilns, it is completely burnt at high temperature and slag which remain as waste, can further utilized as cement and road construction. There is no risk of generation of toxic emission due to the burning of plastics waste in the process and the process is safe as per environmental norms. The establishment like Airport and Railways required developing environmental friendly waste management system for disposal of plastic waste generated from their premises. To reduce the burden of littered/discarded plastics, there is an urgent need for increase public awareness as people are responsible for the pollution caused by plastics.

Chemical treatment methods: These methods are based on the use of chemicals that can break the polymeric linkage of plastics and convert polymers to a nonhazardous state. These methods cannot be used in large-scale operations because chemicals used for plastic degradation will create huge chemical waste debris (Dural *et al.*, 2006). Traditional practices of plastic waste treatment and disposals cause more damage than benefits. The gases emitted by the combustion of plastic wastes are extremely risky and can trigger a range of respiratory disorders. Disposal of plastic waste in municipal waste disposal systems produces poisonous leachate when it gets in contact with soil (Olmedo *et al.*, 2013).

Physical methods: These techniques include physical methods that help in decreasing the volume of plastic waste by the process of squeezing, pulverizing, and incinerating. Some of the commonly used physical methods of waste management include UV degradation and photo-oxidation. Moreover, these methods generate additional environmentally hazardous by-products (Norouzi *et al.*, 2012).

Thermal treatment techniques: Pyrolysis is another method of thermochemical conversion in which solid fuel is burned without the presence of an oxidizing agent (in an inert environment). There are two different techniques of thermal transition: fast pyrolysis for bio-oil manufacturing and slow pyrolysis for charcoal manufacturing (Anyanwu *et al.*, 2018). The gasification process is used for converting carbonated organic or fossil fuel into commonly used gases such as carbon monoxide, hydrogen, carbon dioxide, etc. in the presence of a controlled amount of oxygen or air. The process takes place at extremely elevated temperatures (>600 C) and oxidizes the hydrocarbon which can be used as an energy source (Mirghaed *et al.*, 2018).

Biological methods: In this process, plastic polymers are degraded without producing toxic by-products. Biomethanation is the method of converting organic polymers or solid wastes into methane and manure by microbial intervention. This process takes place in the absence of oxygen through a method called anaerobic digestion (Sures, 2001). Solid wastes from agro-based sectors are used in this process, resulting in helpful products such as biogas and soil manures.

Metal Waste Treatment in India

The Ministry of Electronics and Information Technology (MeitY) has developed affordable technologies to recycle valuable materials and plastics in an environmentally sound manner, including two exclusive PCB recycling technologies, viz 1000 kg/day capacity (~35 MT e-waste) and 100kg/batch (~3.5MT e-waste) processes, with acceptable environmental norms (Malek *et al.*, 2007).

The 1000kg PCB/day continuous process plant would be suitable for creating an eco-park in the country, whereas, the 100kg PCB/batch process plant would be suitable for the informal sector. E-waste also contains plastic, up to nearly 25 per cent of its weight. Novel recovery and conversion of e-waste plastics to value-added products have also been successfully developed.

The developed process is capable of converting a majority (76 per cent) of the waste plastics into suitable materials, which could be used for virgin plastic products (Bamidele & Kuton, 2016). The high-grade metals — like gold, silver, copper and palladium — in the e-waste can be separated for re-sale in conditions that are totally safe. Immense potential is there in augmenting e-waste recycling in the country. There are some forward movements in this direction, however, lots of ground has to be covered through awareness campaign, skill development, building human capital and introduction of technology while adopting adequate safety measures in the country's informal sector.

Since India is highly deficient in precious mineral resources (whereas untreated e-waste goes to landfill), there is need for a well designed, robust and regulated e-waste recovery regime which would generate jobs as well as wealth.

Delhi and the National Capital Region generate 85,000 metric tonnes (MT) of e-waste and this is expected to go up to 150,000 metric tonnes (MT) by 2020, according to Associated Chambers of Commerce and Industry of India (Assocham). A holistic approach is needed to address the challenges faced by India in e-waste management. A suitable mechanism needs to be evolved to include small units in unorganized sector and large units in organized sector into a single value chain. One approach could be for units in unorganized sector to concentrate on collection, dismantling, segregation, whereas, the metal extraction, recycling and disposal could be done by the organized sector.

DISSCUSSION AND RESULT

Aquatic organisms act as a bioindicator that can accumulate plastic-heavy waste in their organs. They induce significant damage to the physiologic and biochemical processes of the organism and subsequently to their consumers. By using parasitism and heavy metals as a bioindicator for pollution of the fish ecosystem, we can detect the health status of the marine environment. Additionally, we found that the parasitism had an environmental impact and demonstrated that parasites are important for biodiversity and development, as well as a healthy system which is rich in a diverse parasite fauna. Using marine organisms as bioindicators of plastic pollution can provide crucial information that would better integrate the spatial and temporal presence of plastic debris in the sea. Given their long and frequent migrations, numerous marine species that ingest plastics can provide information on the presence of plastic debris.

CONCLUSION

In this review, it can be concluded that aquatic organisms play a very crucial role in maintaining and restoring marine life and aquatic environment. Marine organisms help in monitoring and correcting current scenario of the water bodies. Although all these features are difficult to find in single marine organisms, the joint application of different species may allow setting effective campaigns of monitoring. For an indicator to be effective it must provide a true measure of a component of the ecosystem. Selection of effective indicators is best achieved by developing conceptual models of the ecosystem and using these to pinpoint indicators that provide the required information. As toxic waste is being accumulated day by day, current indicators need to be more precise and give more throughputs.

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