



Review Article

Volume 19 Issue 4 - January 2019
DOI: 10.19080/ARTOAJ.2019.19.556104

Agri Res & Tech: Open Access J

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Emerging Contaminants Effect on Aquatic Ecosystem: Human Health Risks-A Review



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Submission: January 06, 2019, **Published:** January 29, 2019

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Abstract

The current chapter deals with different emerging contaminants that are present in aquatic ecosystem and pose a potential threat to the aquatic organisms inhabiting there. Emerging contaminants may be many more of which the most common include trace metals, pesticides, nanomaterials and microplastics. The main source of emerging contaminants includes land-based sources, runoff from agricultural sources and waste water effluents from domestic and industrial sources which ultimately reach the aquatic system which define their fate and transformation. Most of these contaminants are not frequently measured but have the possibility to reach the aquatic ecosystem and cause negative impacts on human health. The above aforesaid emerging contaminants are explained in detail, imparting examples of the most admissible compounds and their characteristics and hazard indicators.

Keywords: Contaminants; Trace metals; Pesticides; Nanomaterials; Microplastics; Aquatic system; Health risks

Abbreviations: UN: United Nations; NOAA: National Oceanic and Atmospheric Administration; PVC: Polyvinylchloride; PS: Polystyrene; PE: Polyethylene; PP: Polypropylene; MPs: Microplastics

Introduction

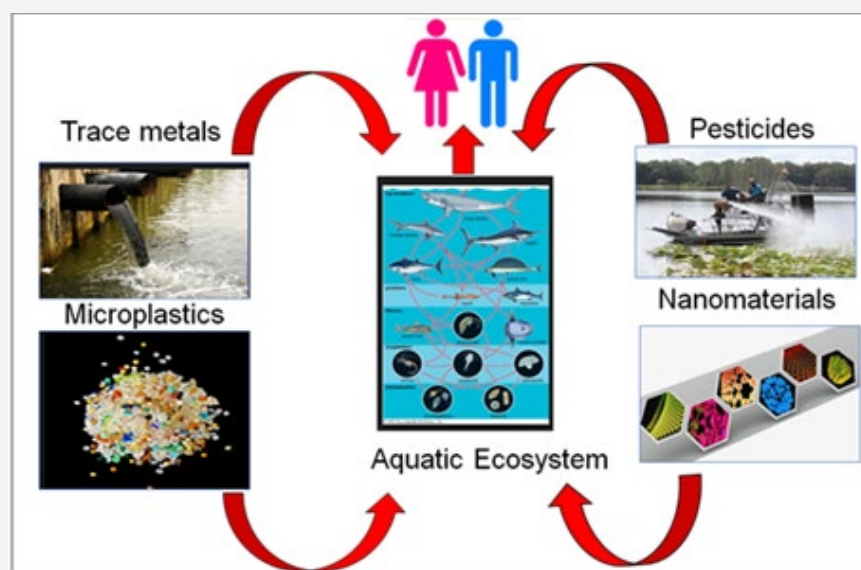


Figure 1: Emerging contaminants entering aquatic ecosystem and their effects on human.

Foot note: Image source from web.

Each day a new chemical contaminant is added into the environment globally and their list is increasing [1]. Most of these chemicals are intended for use in agro based industries or as consumer goods. There should exist a regulation which prevents or control the use of these chemicals before released into the environment. Aquatic pollution is a global problem and need to be monitored immediately and execution of plans to regulate. Each day nearly 2-3 million tons waste from agriculture and industrial are released into the aquatic system [2]. One of the studies conducted by UN revealed that the extent of drain water generated annually is around 15×10^{18} mm³, which is nearly the six times of the water existing in the world. Due to the lack of proper hygiene most of the aquatic sources are contaminated worldwide, leading to significant cause of water pollution. There exists different definitions for the term emerging contaminants and also the different types of materials/chemicals that should be covered in this class. Emerging contaminants are those substances which are not ecosystem and no more usually involved in the repetitive investigation whose effect, behavior, and toxicological effects are unknown. Currently most frequently discussed emerging contaminates include trace metals, pesticides, nanomaterials and microplastics (Figure 1). There is a significant difference between contaminants and pollutants, as all toxicants are pollutants but only those contaminants which can eventually cause severe biological effects are pollutants. These pollutants are converted into higher noxious form upon liability to diverse climatic circumstances such as temperature, pH and salinity which get accumulated in food web and cause serious consequences on health of humans [3]. The emerging contaminants such as trace metals, pesticides, nanomaterials and microplastics are entering into the aquatic ecosystem from numerous sources which usually include waste water effluents from domestic and industrial sources, runoff from agricultural and land-based sources [4].

Trace Metals in Aquatic System

Developing countries reported of trace metal contamination in the water bodies which is considered as one of the major global environmental problem [5]. The different sources of these trace metals include mining, landfills, aerial discharge, geological enduring, dumping from domestic, industrial and agricultural based sources [6]. The trace metals are finding their way into aquatic environment can be held in the water column or gets settled on the fine sediment [7]. Trace metals influences the aquatic organisms by the process of accumulation and magnification biologically [8]. Trace metal contamination was evaluated by various model organisms [9]. During recent past, adequate consideration was made on the hazard involved to health of human while taking into account of the ecosystem itself; hence aquatic organisms are used as model organisms to know the impact of diverse contaminants on the human health [10]. The impact of different trace metals on aquatic organisms is presented in Table 1.

Table 1: Aquatic organisms exposed to trace metals.

Organism	*Contaminants	References
Primary producers, Invertebrates, Insects, fish	Trace metals	Shilla et al. [11], Fang et al. [12]
Aquatic Invertebrates	Trace metals	Radomyski et al. [13]
Fish, shellfish, crab, shrimp	Trace metals	Liu et al. [14]
Aquatic Invertebrates	Trace metals	Hug Peter et al. [15]
Aquatic macroinvertebrates	Trace metals	Rodriguez et al. [16]
Cichlids	Trace metals	Land et al. [17]
Wild marine organisms	Trace metals	Gu et al. [18]
Ruditapes decussatus	Trace metals	Esposito et al. [19]
Benthic foraminifera	Trace metals	Baz and Khalil [20]

*Trace metals content varied in the organisms upon experimental conditions

Pesticides in Aquatic System

Table 2: Organisms with pesticides reported in the literature.

Organism	*Contaminants	References
Algae, Daphnia and Fish	Organophosphorus pesticide	Sumon et al. [22]
Aquatic Organisms	Imidacloprid	Feverly et al. [23]
Aquatic Organisms	Organophosphorus pesticides	Sturve et al. [24]
<i>Ceriodaphnia dubia</i>	Pesticide mixture	Nowell et al. [25]
Aquatic Organisms	Pesticides	Chen et al. [26]
<i>Geitlerinema sp. & Chlorella sp</i>	Triclosan	Tastan et al. [27]
Zebra fish	Pesticides	Wang et al. [28]
<i>B. rerio</i> and <i>D. magna</i>	Pesticides	Li et al. [29] Horton et al. [30]
Aquatic Organisms	Pesticides	Xie et al. [31]

Pesticides are group of chemical compounds usually used to treat a number of plant or animal pests [10]. Pesticides are among the priority contaminants entering into the aquatic environment from various sources causing potential risk to the aquatic organisms in turn effecting the humans [2]. It is noted that unintentional pesticide poisoning had killed several people internationally every year due to the excessive exposure and improper use of pesticides [1]. Most of the pesticides are applied on agricultural soils, they have immense probability to reach the aquatic ecosystem, via overflow, agricultural runoff, rainwater discharges, and also from agricultural fields. Many researches have designed numerous studies to monitor the occurrence of pesticide residues in aquatic systems around the globe and have the intensity to cause severe effects on the health of humans and also the environment at very low concentrations as they are enduring and get accumulated in the organisms [21]. Pesticides reportedly found in aquatic organisms are presented in Table 2.

Nanomaterials Aquatic System

Table 3: Aquatic organisms exposed to nanomaterials.

Organism	*Contaminants	References
Aquatic Organisms	Carbon based nanomaterials	Freixa et al. [38]
Aquatic Organisms	Metals based nanomaterials	Chatel and Mouneyrac [39]
Aquatic Organisms	Metallic nanomaterials	Andreani et al. [40]
<i>Moina macrocopa</i>	Silver nanoparticles	Borase et al. [41]
Aquatic Organism	Copper nanomaterials	Keller et al. [42]
<i>D. magna</i>	Silver decorated zinc oxide nanomaterials	Azevedo et al. [43]
Aquatic Organisms	Mixture of nanomaterials	Du et al. [44]
Aquatic Organisms	Nanoparticles	Canesi et al. [45]
Aquatic Organisms	Engineered nanomaterials	He et al. [46] Callaghan and MacCormack [47]

*Nano-materials content varied in the organisms upon experimental conditions

Nanomaterials are the materials having dimensions less than 100nm. Nanotechnology is a vast and its application has been found in a variety of applications which include electronics, optics, medical devises, sporting gear and also in cosmetic items [32]. Nanomaterials from various point and nonpoint sources are also reaching the aquatic ecosystem as a major sink [33]. Due to their small size nanomaterials are extremely active and possess exceptional chemical, biological and physical properties. Nanomaterials is disposed very slowly as they persist in air, water and are seen transported to larger area than bulk grain of the same composition [34]. The specific nature of nanomaterials augment concern about their toxic impact on biological systems, which at the cellular level, carry architectural preparations that feature materials of nano range [35]. Moreover, the hazardous nature and biotic impact of nanoparticles are not explained completely, and the consequences of nanomaterials in the aquatic ecosystem along with other contaminates is really a virgin field [36]. Various studies were conducted by researchers in order to know the fate, movement and hazardous nature of nano-materials in the aquatic ecosystem. Most of the studies revealed that majority of the engineered nanomaterials both in particulate and ionic form are toxic to the environment. Still further studies are warranted in order to understand the complete mechanism of action of nanomaterials especially to aquatic organisms at their cellular level [37]. In Table 3 different nanomaterials effecting various aquatic organisms are presented [38-47].

Microplastics in Aquatic System

The global production of plastic has reached new records due to the intense utilization of plastic globally. Due to its cost and ease of production has led to the production of numerous numbers of products made of plastic. Among the total aquatic litter found around the world, 60-80% is obtained from plastic waste. Most

of the plastic reaching the aquatic system is of earthbound source, whereas 18% is associated to fishing industry. The term microplastic differs from author to author but the term defined by the National Oceanic and Atmospheric Administration (NOAA), defines the same as microplastic as the materials having < 5 mm in diameter and nanoplastic are usually less than 100 µm diameter. The deterioration of plastic into tiny chunk alters the physical and chemical nature of the plastic and thereby its possibility and harmful effect on aquatic organisms increases.

Table 4: Different aquatic organisms exposed to microplastics.

Organism	Contaminants	References
Aquatic Organisms	Microplastics	de Sa et al. [53]; Harmon [54]; Wang and Wang [55]
Marine Organisms	Microplastics	Guzzetti et al. [56]
Marine Microalgae	Microplastic with triclosan	Zhu et al. [57]
Marine Organisms	Microplastics	Wang et al. [58]
<i>S. Plana</i>	Microplastics	Donovan et al. [59]
Aquatic Organisms	Nanoplastics	Mattsson et al. [60]
<i>B. koreanus</i>	Microplastics	Jeong et al. [49]
<i>A. parthenogenetica</i>	Microplastics	Wang et al. [58]

*Microplastics content varied in the organisms upon experimental conditions

Plastics are materials which are derived from petroleum products which usually include polyvinylchloride (PVC), nylon, polystyrene (PS), polyethylene (PE) and polypropylene (PP). Pollution from plastic is a global environmental problem and concerns about this issue are increasing. Due to their ease of production and inertness these plastics are produced in large scale around the world and their global production has reached 8300 million metric tons till dated [48]. The high strength, resistance to water and their low cost made them a suitable candidate for use in diverse applications. Moreover, aquatic systems are seen receiving plastic through a number of routes and these have raised severe concerns about their threat to the aquatic organisms and health of humans. Due to their unique properties the plastic degrades very slowly in the environment resulting in the generation of plastic particles smaller than 5mm usually known as microplastics (MPs), which are found in various sizes and shapes for instance fibers, fragments and spherules which are acting as carriers for persistent organic pollutants which spread easily and get accumulated in the aquatic organisms [49]. Latest reports reveal that MPs presence as universal in waste effluents from industries, house hold, urban estuaries and surface waters [50]. Both aquatic and terrestrial systems are effected by MPs pollution and the research over the past few years had shown that plastic from different sources are seen entering into the organisms via entanglement and ingestion [51]. Because of their miniature nature these MPs are freely available for ingestion to a number of organisms including invertebrates, fish, marine mammals other filter feeding organisms and in turn effecting humans [52]. The

impact of microplastic on different aquatic organisms is presented in Table 4.

Conclusion

The most serious consequences faced by the aquatic system are the possible ecological impacts linked with various incoming pollutants. Although, the explicit impacts of the effects caused by the environmental pollutants (trace metals; pesticides, nanomaterials; microplastics) on ecosystem is not straight forward, as there is void of information on the existence of various novel emerging pollutants, on their consequences and role in the ecosystem and on their extended effects on ecosystem. In extension, the ecotoxicological understanding of many pollutants and the impact of other chemicals interference remains unknown and the new methods adopted to analyze the hazardous nature of contaminants to humans.

Acknowledgement

Authors acknowledge Vignan's Foundation for Science, Technology and Research University for providing facility for preparing this manuscript.

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DOI: [10.19080/ARTOAJ.2019.19.556104](https://doi.org/10.19080/ARTOAJ.2019.19.556104)

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