E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(3): 235-243
© 2020 IJFAS
www.fisheriesjournal.com
Received: 28-03-2020
Accepted: 30-04-2020

Kavya Tanna
Department of Botany,
Bioinformatics and Climate
Change Impacts Management,
University School of Sciences,
Gujarat University, Ahmedabad,
Gujarat, India

Dr. Dhara Bhavsar
Department of Botany,
Bioinformatics and Climate
Change Impacts Management,
University School of Sciences,
Gujarat University, Ahmedabad,
Gujarat, India

Dr. Archana Mankad
Department of Botany,
Bioinformatics and Climate
Change Impacts Management,
University School of Sciences,
Gujarat University, Ahmedabad,
Gujarat, India

Corresponding Author:
Kavya Tanna
Department of Botany,
Bioinformatics and Climate
Change Impacts Management,
University School of Sciences,
Gujarat University, Ahmedabad,
Gujarat, India

Aquatic toxicity impacts on behaviour and survival of fresh water fish: A review

Kavya Tanna, Dr. Dhara Bhavsar and Dr. Archana Mankad

Abstract

The earth has only 3% of freshwater out of all the water available on the earth and only 1.2% water can be utilized as drinking water. It is thus quiet clear that freshwater ecosystem consists only 3% of all ecosystems on earth. Aquatic toxicity is the measure of contamination in aquatic ecosystem and its impacts on inhabiting organisms. The toxics generally found in aquatic ecosystem are metals, fertilizers, micropollutants and macropollutants. The sources of these pollutants are mostly due to industrial discharge, run off or anthropogenic activities. The toxic effects are lethal and sub lethal both, which may change development, growth rate, reproduction, biochemistry, physiology and behaviour. The toxics are added to water body as a result of runoff residue which is extremely hazardous and harmful to fish. There are emerging concerns about these toxics and its hazardous impacts but comparable research is not reported in freshwater environments. Present study aims to investigate the occurrence and impact of toxics on aquatic species. The importance of such fishes are food web management, regulation of carbon flows, sediment strength and ecosystem links. Hence, freshwater fish populations should be protected and preserved in natural habitat. The purpose of the paper is to highlight the contaminants in freshwater and their impact on adjoining species; responding with different behavioural changes as we are closely associated with it.

Keywords: Aquatic toxicity, metals, fertilizers, micropollutants, macropollutants, behavioural response

Introduction

All living organisms require several essential trace amount of metal during their lifecycle. Several metals become assimilated as vital factor in biochemical functions since prokaryotes and eukaryotes evolution, more or less in accordance with abundance of metals on the planet.

Toxic pollutants like heavy metals are severe in their action due to their tendency of bio-magnification in food chain. Globally, heavy metal pollution in water is major environmental problem. Agricultural and industrial evolution form past decade is responsible for most of water sources contamination. (Khare and Singh, 2002) [32]. Industries discharge harmful effluents to the adjoining water bodies including heavy metals. This lead to terrific aquatic as well as marine pollution.

The Lethal pollutant changes water quality and feeding, swimming behaviour of fish and also delay hatching. Fish has complex lifecycle; in each stage form egg, larva to adult fish they require different habitat for survival. They have ability to absorb metal directly from contaminated water or indirect from feeding on living organism in contaminated water (Javed, 2005) [30]. There are four possible routes for metal entry in fish: food, drinking water, gills and skin. Fishes are abstemiously sensitive to adjoining environment changes. Hence, fish health is important indicator for aquatic ecosystem. (Mokhtar *et al*, 2009) [40]

Extensive use of chemical fertilizer and pesticides, discharge of untreated domestic waste water and effluent discharge are global problem for aquatic pollution. Metal are unique among all chemicals as they are hazardous to ecosystem. Metal pollution of river, lake, water bodies is often reported and they accumulate in the tissue of aquatic organisms. (Anandhan and Hemalatha, 2009) [5], (Saeidi and Jamshidi, 2010). The higher metal concentration ultimately affect the growth and ability of organisms. It can cause harmful effect on metabolic, physiological and biochemical system of fishes (Shalaby and Abbas, 2005)

Fish poisoning can be acute, sub-acute or chronic for human health. Uncertainty, edible fish species are polluted with chemicals causes' lethal effect and lead food insecurity. The toxicity of a particular product can vary from species to temperatures, pH and compositions of ions

(Wlasow et coll., 2010). Waste material and microbial degradation products can thus reach toxic levels in recirculation systems. The vulnerability of aquatic organisms to infectious disease can increase by chemical poisoning and other environmental stressors (Morley, 2010) [41]. The toxics of aquaculture column are different from those of the soil which have different problems for different segments in the aquaculture field in terms of the water quality (Rudolph *et al*. 2009).

Fish can be raised in a confinement such as pool, pond or tank. Typically, cultivated fish are partially or fully dependent on humans for food and are totally dependent for their habitat. Inland aquaculture also requires, to conserving water resources and atleast little hydrological and mechanical management.

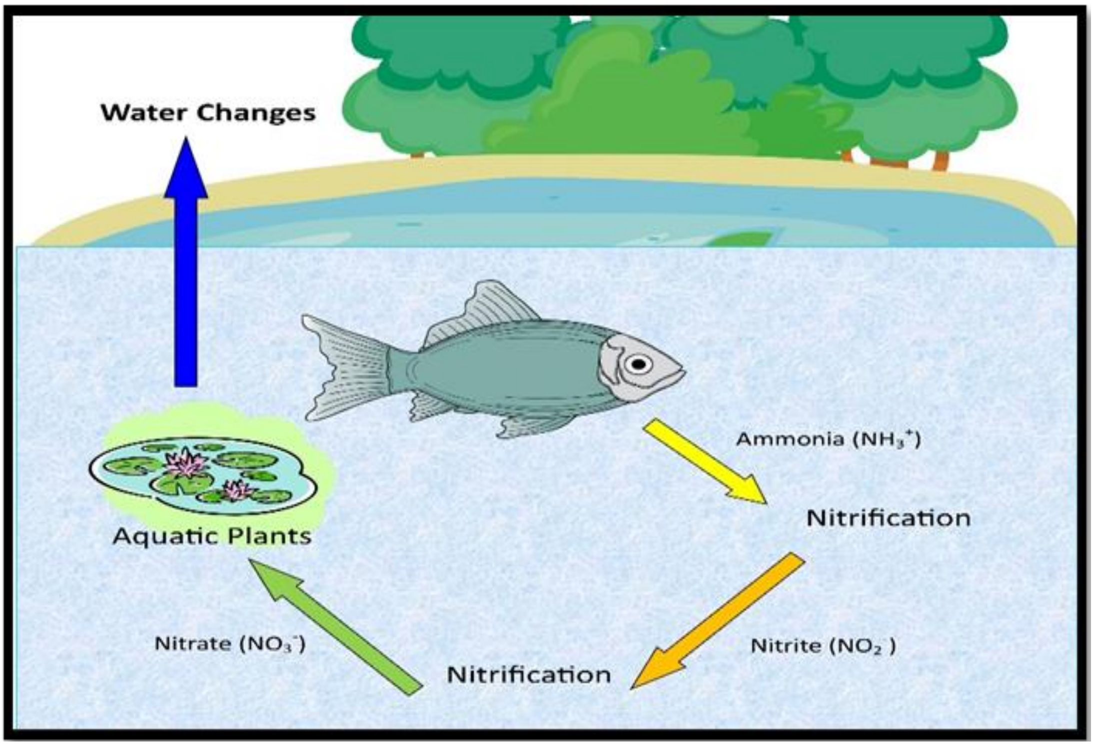
Water Safety Importance

Usages of potentially harmful substances like pesticides, heavy metals and hydrocarbons are released into the aquatic ecosystem. When large amount of pollutants is released into water bodies there may be immediate impact by large scale immediate mortality observed in aquatic organisms. Fish kills along with contaminated water will be additional problem to water bodies.

Within lakes and reservoirs, polluted water kills more fishes than all other deaths. The physiology of fish can influence the stability of environment in which it resides and water parameter from safe to insecure will alter their metabolism interacting with other aquatic species. It especially applies to recirculation systems and high densities stocking. Aquaculture's exposure to water parameters varies with fish age and developmental stage (Finn, 2007) [19]. In terms of solubility of metals, for instance pH of water is significant. Increasing pH typically decreases metals' bioavailability by incorporating organic matter complexes in the water.

Nitrogen Cycle

The nitrogen cycle in aquatic system is of critical importance, particularly in closed system. The nitrogen cycle in an aquatic system is primarily regulated by biota. The Geobiochemistry was achieved through nitrogen cycle. (Hargreaves, 1998). The nitrogen cycle is transforming organic nitrogen, ammonia and nitrogen into nitrogenous gas. Ammonium, nitrite and nitrate are most common ionic forms of nitrogen (Camargo *et al*. 2005) [10]. Atmospheric precipitation, nitrogen accumulation, organic matter and agronomic fertilizer in surface and ground water are sources of the ions. The NH_3 and NO_2 are most dangerous in water ecosystem. Changes in water cycle may also be seasonal or in conjunction with changes in environmentally controls or indoor conditions. In the western countries, for example NO_2 poisoning is more severe in fall and spring (Durborow *et al*. 1997) [14]. When the volume is less than 1 µmol of NO_2 it is generally thought that the water is not contaminated. (Jensen 2003) [31].



https://cafishvet.com

Fig 1: Representation of Aquatic Nitrogen Cycle

For economic reasons, recirculation system may have densities of up to 0.3 kg of fish/ kg of water, leading to high NH_3 loads. Fish is highly toxic to ammonia. Total NH_3 nitrogen requires surveillance as NH_3 is the main and most harmful freshwater fish nitrogen waste. Full NH_3- nitrogen 1NH1 4 types, is the best predator of water safety. Low level of toxicity is the ammonium ion. Estimated fish production NH_3 of NH_3 produced for every kilograms and nitrogen excreted in 24 hours is 0.02 kg of NH_3 nitrogen released for each kilograms (Masser *et al*., 1999; Ip and Chew, 2010) [29]. Increasing NH_3 in fish increases cytosol, glycolysis and decrease the mitochondrial TCA cycle and the brain is susceptible. Increased NH_3 in blood decreases physical activity. Metabolic disorders tend to be present in the liver and contributes to neuromuscle transmitter disturbance and skeletal electrochemistry (Randall and Tsui, 2002). Increasing ammonia in water reduces swimming skills. Diminished swimming ability is related to white muscle depolarization and increase in calcium ion enhanced ammonia toxicity. Fed fish seems to offer some protection against environmental NH_3 toxicity possibly with decreasing glucogenesis (Wicks and Randall, 2002). Immune removal can also take place.

Ammonium is oxidized to nitrate by aerobic bacteria in a two-step process. The risk of NO_2 poisoning is greater than that of terrestrial organisms for aquatic animals, especially freshwater and crustacean fish (Camargo *et al*., 2005) [10]. Aquatic animal nitrite overdose occurs when there are factors in the nitrogen cycle that cause imbalance. Freshwater fish have a higher NO_2 sensitivity than saltwater. NO_2 is consumed rapidly through the gills of freshwater fish. Nitrite also reaches red blood cells and oxidizes Fe_{12} (ferrous) to Fe_{13} (ferroic) hemoglobin (Grabda *et al*., 1974) [22] and methemoglobin (methHb). A common diagnostic characteristic of methemoglobinemia is the decoloration of blood brown. Fe_{12}-Fe_{13} oxidation shifts the relationship of Hb oxygen and blood oxygen tensions to dissolved oxygen in ambient water. It seems to take several weeks to recover from nitrite toxicity, so weight gain may or may not occur. There are a variety of NO_2-species that are related to gills in C_{12} (Durborow *et al*., 1997; Jensen, 2003) [14, 31]. The addition of C_{12} to the water (Durborow *et al*., 1997) [14] can prevent nitrite poisoning. The most common way to achieve a C_{12}-NO_{22} ratio is to add C_{12} to water 10:1. Reduced feed rate and increased non-recycled water performance are alternative control methods for NO_2. The sensitivity of fish to poisoning NO_2 is increased by bacterial and parasitary diseases. The existence of multiple infectious diseases means that environmental C_{12} level are increased. Dietary vitamin E can also be protective against nitrite poisoning.

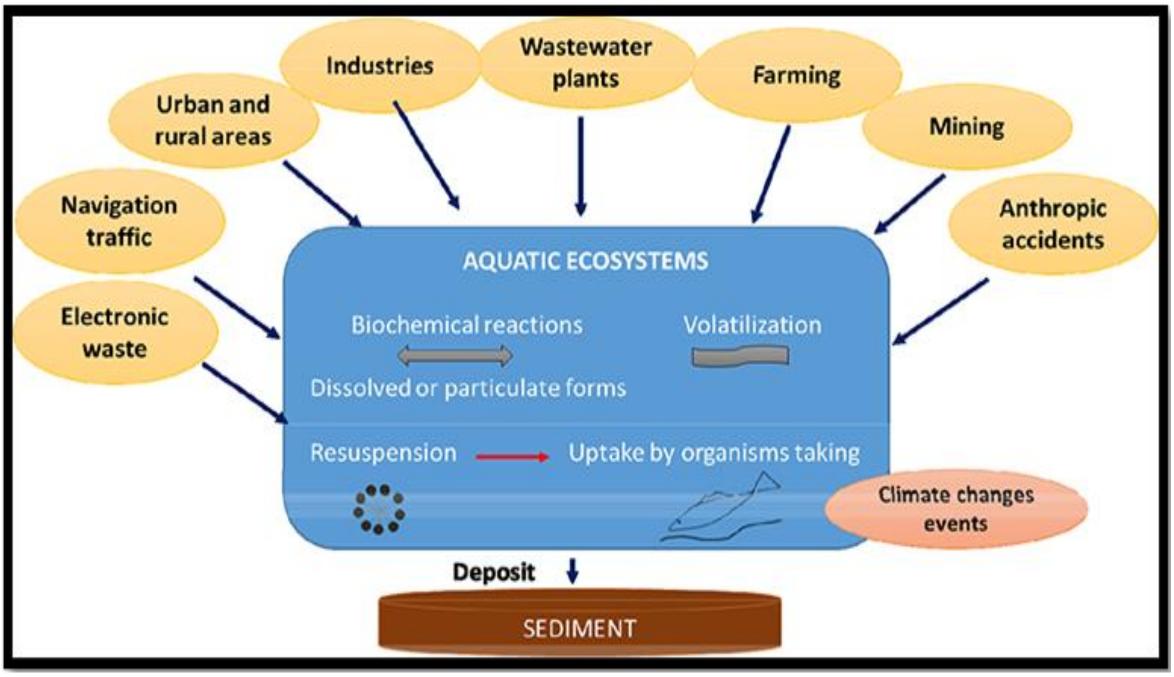
Fish are relatively resistant to NO_2 poisoning compared to NH_3 and NO_2. Accumulation of nitrate may be 1.100 mg of water with NO_2/L. Nitrate poisoning is usually associated with unintended rises due to high-nitrate runoff water contaminants. Larval forms of fishes are usually the most vulnerable phases of life. If there is a detectable chlorine (Cl_2) level, water is not considered safe for fish, and should not be confused by chloride ions (Cl_2). The morbidity of 0.02 ppm (Cl_2) is likely, and the mortality rate of 0.04 ppm (Cl_2) may include 2 ppm (Hadfield *et al*. 2007) [23]. The disinfectant agent in municipal water and aquaculture is chlorine, chloramines and other chlorinated substances to disinfect ponds and tanks. The chlorine gas applied to water makes many components of the concentration of dissociated ions depending on the pH of the water (hypochlorine acid, hydrochloric acid and hypochlorite). The toxicity of chlorine dioxide to fish is around 16 times that of chlorite. Safe levels of chlorine dioxide seem to be around 0.2 ppm and about 3 ppm of chlorite for rainbow trout. With change in temperature, the toxicity of Cl_2 residues is variable. Residual Cl_2 in the water is generally oxidative and causes irritation and damage to the gills.

Aquatic Toxicity by Metals

Heavy metal is a main concern due to its toxicity and a danger to plant and animal life in the aquatic environment, thus disturbing the natural ecological balance (Bhattacharya *et al*, 2008) [8]. The rate of entry into aquatic systems of heavy metals is alarming. The accumulation of heavy metals above natural loads in aquatic ecosystems has become a major problem over the past decades and a topic of concern (Voegborlo *et al*., 1999; Canli *et al*., 1998; Dirilgen 2001; Vutukuru, 2005) [11, 13]. Effluents are released into water systems directly or through rivers, leaching or drainage (Ezemonye and Kadiri, 2000) [18] by the means of human activities such as industrialisation, urbanization and farming. Within marine biota (USEPA, 1991) and food chains, heavy metals and organically active compounds can be bioaccumulated. Fish are therefore affected by health, growth, growth and survival. The characteristics of heavy metals are their strong attraction and slow removal from biological systems to biologic tissues (Nwani *et al*., 2009).

Cadmium: Cadmium (Muthukumaravel *et al*., 2007) [43] is the most poisonous and essential heavy metal in the earth's crust and water environments. Cadmium occurs naturally in certain phosphate rocks, which can account for high levels of cadmium in phosphate fertilizers including superphosphate fertilizer (Geisy 1978; Oronsaye 2001). As cadmium production and use has continued to increase rapidly and persistently over the years, with increased urbanization and industrialization (Akan e t a l, 2009) [2]. The loss of cadmium-treated agricultural land is projected to enrich the aquatic ecosystem by metals (Oronsaye, 2001). Cadmium can be dumped into surface water as an effluent and has a number of industrial applications and can be measured by metal (Onuoha *et al*. 1996; Oronsaye 2001). For some aquatic life, cadmium is highly toxic (Mason, 1996) [38], particularly to fish (Suresh *et al*., 1993). Fish bioaccumulate through different gateways heavy metals like cadmium. The acquaintance with a medium which carries the chemical in solution or in the suspension is particularly important because the fish have to extract oxygen from the medium by passing huge amounts of water over the gills (Akan *et al*., 2009) [2]. Cadmium has deleterious effects on fish (Vinodhini and Narayanan, 2008; Akan *et al*., 2009) [2]. The gill, skin, and digestive tract are possible absorption sites for waterborne chemicals.

Zinc: Zinc is one of the most fundamental and common heavy metal contaminants (Kori Siakpere *et al*. 2008) [33]. Which can be found in the waters of natural waters through geological rock weathering or human activities, such as wastewater and waste disposal, where they form an integral part of the conservation function of the cytoplasma (Weatherly *et al*., 1980; Kori -Siakpere *et al*., 2008) [33]. It has a vital role as a structural element that has life-required properties (Bengari and Patil, 1986; Murugan *et al*., 2008) [7, 42]. Zinc may continue for years without decomposition because it is an unnatural substance. Zinc is sub lethal poisonous for fish and macro invertebrates (Folorunsho and Oronsaye 1990; Ajiwe *et al*, 2000; Nsofor *et al*. 2007) [1]. While critical component (Dimari *et al*., 2008) [12], in potential adverse effect to fish (Everall *et al*., 1989; Murugan *et al*., 2008) [17, 42]. The main sites of zinc accumulation in fishes are liver and kidney (Murugan *et al*., 2008) [42].



https://www.intechopen.com

Fig 2: An image representing effects of metals in aquatic ecosystem

Lead: Mason (1996) [38] examined that residues contain lead heavy metals are significant freshwater contaminant. Because of its inclusion in petrol, lead is primarily released to the atmosphere through vehicle exhaust pipes (Nsofor *et al*., 2007). Fish bioaccumulate in different organs such as gills, stomachs, liver and intestines. The biological effects on fish of sublethal plum levels are shown.

Copper: Okoye's (1991) reports said that copper is one of the heavy metal enrichment for Lagos lagoon, which involved urban and industrial waste inland. The gill is an important site for the introduction of copper (Vinodhini and Narayanan, 2008) and Hepatitis, stomach and intestine are another. Copper pollution adversely affects fish and its high concentrations in peaches may be toxic (Woodward *et al*., 1994). Copper can combine to produce toxic additives to fish with other contaminants such as ammonia, mercury and zinc (Herbert and Vandyke, 1964; Rompala *et al*., 1984) [27].

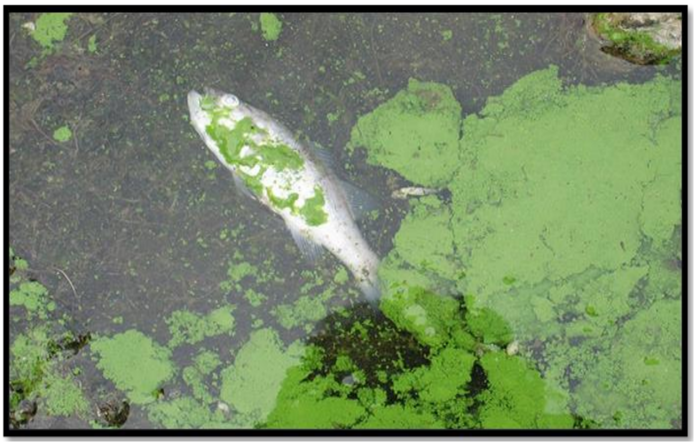
Heavy metals are diffuse and conservative pollutants which bioaccumulate, biomagnify and damage the aquatic ecosystems along the food chain. While cadmium, zinc, plum and copper are important for metabolic processes, efforts should be made to ensure that they and other heavy metals do not exceed acceptable limits for the WHO and the FEPA. All environmental policies and public education programs on how important it is for water systems and their resident biota to be protected and maintained should be strengthened.

Aquatic Toxicity by Fertilizers

Large quantities of nitrogen and phosphorus enter into the seas and the oceans through rivers. Phosphorus is almost meaningless atmospheric transportation. The nitrogen intake into the Baltic Sea is measured at one third, and the air flow into the North Sea and the Mediterranean is equivalent. Airborne nitrogen content depends on many factors, including industrialisation, traffic, atmosphere, etc. Deposition of nitrogen in Europe comes approximately from both nitrogen and ammonia oxides. Large amounts of nitrogen and phosphorus flow through the rivers in the seas and oceans. Nitrogen inputs mean permanent and additional fertilization that could not be harmful unless the vital load is exceeded. The critical burden of nitrogen eutrophication is described as a "quantitative estimate of the exposure to deposition of nitrogen as ammonia and/or nitrate underneath which damaging effects do not occur in terms of the structure and function of the ecosystem according to existing knowledge" (EMEP 1997).

Rivers

Rivers capture the water from the hydrological basin and address substances containing nutrients and trace components on their way through the soil, rocks etc. Water used for human activities and rivers have been heavily polluted by the input of untreated and processed waste water from municipalities and industries as well as from farming activity. Over the past three or four decades, the rise in nutrient intake of agriculture into rivers has always tripled or increased and in many countries is well established (Loigu, 1989, Enell *et al*, 1989) [37, 16]. Rivers are not fertilized, yet the environment is influenced indirectly by fertilization, i.e. not by the fertilizer itself, but by the effect that it creates. Indirect impacts are nitrification oxygen demand due to microbial oxidation of ammonia. Increase in the production of primary planktons, macrophytes, and other water plants by increasing nutrient availability and use, and finally for inorganic nitrogen and phosphorus compounds. Toxic ammonia formation (NH3) assisted indirectly by fertilization, provided that the above-mentioned primary production intensification produces large quantities of organic nitrogen-containing material mineralized to ammonium ion. Full ammonia (NH4+NH3) does basically depend on the pH and water temperature for the percentage of non-ionized ammonia (Hamm 1991). Regular fluctuations in eutrophic waters are often increased to more than 9 with the pH value, changing the overall ammonia balance to syndicate ammonia. Another effect of eutrophication is a possible rise of water level, in conjunction with increasing friction, by the excessive growth of macrophyte. The ecosystems will be affected in both the water and banks.



https://www.conserve-energy-future.com

Fig 3: Representation of Eutrophication caused by use of fertilizers

Lakes

Lakes have their own hydrological basin or, as far as fertilizer effects are concerned, are along a river, i.e. they are similar to rivers. Also, because there are no direct impacts (for instance the indirect effects via ammonia, together with a high pH and temperature) in rivers, the indirect ones are also real. The significant difference obviously is that the time spent living in the water remains the average time a water molecule and other products. Thus, pollution-damaged rivers can be healed much more easily than lakes that retain the substance longer. The results of eutrophication are seen as green belts in shallow waters by shed and macrophyta, leaving lake vulnerable to nutrients. The floor of the lakes is also covered by phytoplankton. In order to mineralize the organic material, a high primary production produced through the availability of nutrients creates a high demand for oxygen. Anoxic environments inhibit life for both animals and plants, i.e. the damaged ecosystem.

Sea and Oceans

Oceans receive many substances via water-resolved rivers or transported by friction as unresolved material. In fact, the atmosphere absorbs different substances. The accumulation of chemical elements in oceanic waters is relatively stable over long periods due to the relatively small annual amount by rivers and the atmosphere as compared to the quantity already settled in the seas. It is not true that coastal areas affected in particular by river water and nutrients. Eutrophication often affects coastal areas. The input of nitrogen into the oceans is also concerned, in particular in sections of which nitrogen is the limit or of biological growth (such as Antarctic water). Eutrophication may also lead to the explosiveness of algae-" red tides-which "cover the sea surface and cause enormous losses in commercial fishing.

Hence, there is a need for marine ecosystems to be protected. It time for action now which assisted amongst others in relation to the scientific aspects of Marine Environmental Protection (GESAMP) by the IMO / FAO-IOC / WMO / WHO / IAEA / UNEP Joint Group of experts. This working group concluded that land activities are the main sources of ocean problems and threats. During the last decade, some important milestones have been achieved and raising the negative impact on maritime and coastal land-based activities. Unfortunately, the degradation of the oceans and coastal regions from a global perspective has continued and even intensified in many places. In the coastal areas, depletion is much harder than in the open ocean. Land-based practices have the most serious problems like

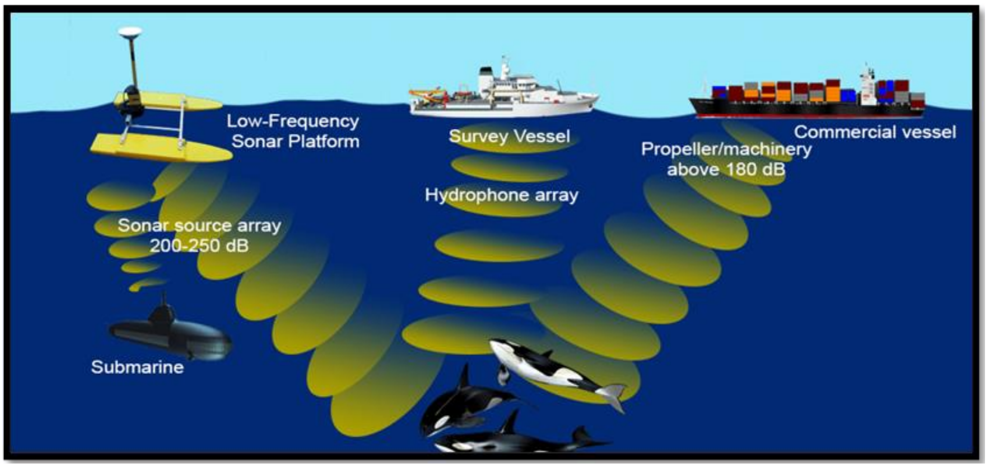
- Habitat and ecosystem modification and degradation
- Human health influence of pollution
- Widespread and intensified eutrophication
- Sediment-flow changes due to change in the hydrology.

The information available includes a reduction in nutrient pollution in seas and oceans. This awareness must now be turned into motion. Nonetheless, the crucial question is whether worldwide political strength and financial power support this goal.

Contaminants in Aquaculture Fishes

Animals from aquaculture are a major source of eco-persistent organic chemicals. These chemical substances are biomagnified in fish and animals that consume them. Such compounds are also transferred during pregnancy into the human fetus and excreted during lactation in breast milk. The prenatal and early postnatal period are the most sensitive stage of life, including humans, for adverse effects. Depending on the specific chemical and animal species, endocrine disorders and symptoms have been identified. The primary source for cultivated fish is dietary animal protein, fat and clay.

Acoustic Pollution and Fish



https://www.marineinsight.com

Fig 4: Representation of Acoustic Pollution

Substantially determined by temperature, friction and, to some degree, salinity, the distribution of sounds in water (NOAA, 2000). Under water, long stretches of low frequency sound can be propagated. For a variety of environmental experiences and interactions with each other, Fish use sound sensors (NAS 2016). For locomotion in the aquatic environment, pressure sensors are also important. Noise pollution is vulnerable to masking or changing hearing levels, auditory disruption and adverse stress reaction (Peng *et al*., 2015). Larval and embryos exposure to noise can lead to reduced survival of fish (Brown *et al*., 2016) [9]. A plausible explanation is the decrease in capacity to control the marine climate.

Behaviour Response of Fish

The physical, chemical and perceived stressors can evoke unspecific responses in fish and make it possible for fish to cope with disorders. Subcellular responses should be related to behaviour, chemical stress, and higher organism levels. As behaviour stems from endogenous and exogenous processes, changes in these parameters can also lead to the understanding of the health and viability of gene-exposed natural populations. In order to adapt or cope with disturbances, stressors evoke a nonspecific response in fish. If stress is longer, however, the prosperity of fish may be jeopardized (Barton BA.). When the animal is exposed to lower chemical levels that could contribute to mortality, behavioural changes may be noticed (Little EE, Finger SE). (Scott GR, Sloman KA). Study has indicated that the utility and significance of conduct indicators should be increased by interdisciplinary research.

Feeding Behaviour

Some improvement in fish behaviour offers information and knowledge on behavioural modifications which can be correlated in aquatic species with physiological biomarkers (Hellou J.). The behaviour, which is very responsive to environment and chemical exposure, combines physiological function with ecological processes. Ecotoxicology studies is the use of behavioural alterations in organisms in response to pollutants in order to better determine ecologically relevant endpoints for risk. There is ecological significance to behavioural changes related to feeding (Alonso A, Valle-Torres G.). This contributes to the location and access to food which can affect population dynamics and eventually the structure of the society. Swimming and avoidance behaviour, both of which involve deciding fish's survival, such as food supply and avoiding adverse conditions, have a direct effect on their appetite (Sabullah MK, Ahmad SA, Shukor MY, Gansau AJ, Syed MA, Sulaiman MR *et al*.). Reduced feeding behaviour effects growth and reproduction, may reduce the energy consumption of the organism.

Swimming behaviour

Swimming behaviour is known to be a criterion for determining the physiological status of the aquatic environment in the presence of contaminants (Almeida GFD, Hinchsen LK, Horsted K, Thamsborg SM, Hermansen JE.). Swimming activity is one of the most frequent and easily measured behavioural responses in toxicological studies (Little EE, Archeski RD, Flerov B, Kozlovskaya A.). Since many aspects of fish biology rely on swimming, lower performance could have a significant impact on interspecific and intraspecific interactions, eventually reducing the fitness of individuals. (Hopkins WA, Snodgrass JW, Staub BP, Jackson BP, Congdon JD.).Changes demonstrated by an organism in response to a chemical depend on its mode of action (Robinson WS.). Compartmental changes were investigated in response to certain chemicals such as chlorpyriphos (Rice PJ, Drewes CD, Klubertanz TM, Bradbury SP, Coats JR.), polychlorinated biphenyles chromium(Mishra AK, MohantyB.), and tributyltin (Schmidt K, Steinberg CEW, Pflugmacher S, Staaks GBO.). Numerous studies to assess the toxicity of a compound, swimming activities had been used before. Swimming performance by metals by increasing the plasma ammonia concentration that reduces plasma Na+, K+, Ca2 + levels. Such ions include multiple metabolic and physiological processes including central and peripheral nerve activity, muscle contraction, neuromuscular junction transmission, etc.

Avoidance behaviour

The behaviour of rainbow trout (avoidance) is demonstrated when the water is exposed to oil sand process (Lari E, Pyle G.). In an inquiry by, control fish kept active in normal water throughout the trial were found irregular habits such as rapid swimming, increased activity of the operculum and decreased reflexes, but in fish exposed to 4-nonylphenol. There have also been high pigmentation and high mucus secretion. The action of avoidance was shown through moments of jerky and fish were often gulped on the water. When the water is subjected to oil sand process (Lari E, Pyle G.), the rainbow reality avoidance activity is demonstrated. In the investigation by Sharma M, Chadha P, Borah MK. control fish were found to have unusual behaviours such as swimming, increased operculum activity or weakening reflexes with High pigmentation and mucus secretion have also observed Moments of jerky and fish were often hit on the water revealed the practice of avoidance.

Conclusion

Fishes are being captured and concentrated to expand aquaculture, breeding, display and many more similar human activities. Aquatic organisms used as food, is increasing worldwide. To obtain healthy aquatic organisms, we need to clean and maintain clear aquatic ecosystem, so to get safer foods and by-products produced. Multiple use of water resources is the biggest problem faced by aquatic organisms. Hence, watching and securing incoming water flows, to give a better clean and healthy outflow of water in improved conditions is required. However, for the food and feed safety, additional future research is required to accurately diagnose diseases caused in aquatic organisms by chemical and physical agents.

References

1. Ajiwe VIE, Nnabuike RO, Onochie CC, Ajiobola V. Surface water pollution by effluents from some industries in Nnewi Area. Folournsho, B. and Oronsaye, J. A. O. The toxicity of cadmium to Clarias angularias in soft water. Nigerian Journal of Applied Sciences. 1990; 8:85-92.
2. Akan JC, Abdulrahman FI, Sodipo OA, Akan U. Bioaccumulation of some heavy metals in six freshwater fishes caught from Lake Chad in Doron Buhari, Maiduguri, Borno State, Nigeria. Journal of Applied Scie ncesin Environmental Sanitation. 2009; 4(2):103-114.
3. Almeida GFD, Hinchsen LK, Horsted K, Thamsborg SM, Hermansen JE, Feed intake and activity level of two

broiler genotype for foraging different types of vegetation in the finishing period. Poultary Sciences. 2012; 91:2105-2113.

4. Alonso A, Valle-Torres G. Feeding Behavior of an Aquatic Snail as a Simple Endpoint to Assess the Exposure to Cadmium. Bulletin of Environmental Contamination and Toxicology. 2018; 100:82-88.
5. Anandhan R, Hemalatha S. Acute toxicity of aluminiu to zebra fish, *Brachydanio rerio* (Ham). Int J of Vet Medi.; 2009; 7(1).
6. Barton BA. Stress in fishes: A diversity of responses with particular reference to changes in circulating corticosteroids. Integrative Comparative Biology. 2002; 42:517-525.
7. Bengari KV, Patil HS. Respiration, liver glycogen and bioaccumulation in *Labeo rohita* exposed to zinc. Indian Journal of Comparative Animal Physiology; 1986; 4:79-84.
8. Bhattacharya AK, mandal SN, Das SK. Heavy metals accumulation in water, sediment and tissues of different edible fishes in upper stretch of gangetic West Bengal. Trends in Applied Science Research; 2008; 3:61-68.
9. Brown AD, Sisneros JA, Jurasin T. Effects of hatchery rearing on the structure and function of salmonid mechanosensory systems. Adv. Exp. Med. Biol; 2016; 875:117 124.
10. Camargo JA, Alonso A, Salamanca A. Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. Chemosphere. 2005; 58:1255 1267.
11. Canli M, AYO, Kalay M. Levels of heavy metals (Cd, Pd, Cu and Ni) in tissue of Cyprinus carpio, *Barbus carpio* and Chondrostoma regium from the Seyhan River. Turkish Journal of Zoology. 1998; 22(3):149 – 157.
12. Dimari GA, Abdulrahman FI, Akan JC, Garba ST. Metals concentrations in tissues of *Tilapia galilaeus*, Clariaslazera and Osteoglossidae caught from Alau Dam, Maiduguri, Borno State, Nigeria. American Journal of Environmental Science, 2008; 4(4):373-379.
13. Dirilgen, N. Accumulation of heavy metals in freshwater organisms: Assessment of toxic interactions. Turkish Journal of Chemistry; 2001; 25(3):173-179.
14. Durborow RM, Crosby DM, Burnson MW. Nitrate in Fish Ponds. Southern Regional Aquaculture Center, Stoneville, MS, 1997.
15. EMEP/MSC: W Report Part one: emissions, dispersions and trends of acidifying and eutrophying agents. The Norwegian Research Institute, Research Report 1997, 48;
16. Enell M, Ryding SO, Wennberg L. Nitrogen and phosphorus impact of agricultural activities on air and water. In: Laikari H(ed) River Basin Management-V; Proc IAWPRC, Frankfurt: Pergamon Press; 1989, 203-212.
17. Everall NC, Macfarlane NAA, Sedgwick RW. The interactions of water hardness and pH with the acute toxicity of zinc to the brown trout, *Salmo trutta* L. Journal of Fisheries Biology. 1989; 35:27-36.
18. Ezemonye LIN, Kadiri MO. Biorestoration of the Aquatic Ecosystem: The African perspective. Environmental Review. 2000; 3(1):137-147.
19. Finn RN. The physiology and toxicology of salmonid eggs and larvae in relation to water quality criteria. Aquat. Toxicol. 2007; 81:337 354.
20. GESAMP Asea of trouble / UNEP. GESAMP reports and studies 70, ISBN; 2001; 9(82):7701-010.
21. Giesy JP. Cadmium inhibition of leaf decomposition in an aquatic microcosm. Chemosphere. 1978; 7:457-475.
22. Grabda E, Einszporn-Orecka T, Felinska C, Experimental methemoglobinemia in rainbow trout. Acta Ichthyl. Piscat. 1974; 4:43-71.
23. Hadfield CA, Whitaker BR, Clayton LA. Emergency and critical care of fish. Vet. Clin. North Am. Exot. Anim. Pract. 2007; 10:647-675.
24. Hamm A. (ed) Quality objectives for the inorganic nitrogen and phosphorus (nutrients) in running waters; Summary. Sankt Augustin : Academia, 25-39
25. Hargreaves JA. Nitrogen biogeochemistry of aquaculture ponds. Aquaculture. 1991; 166:181-212.
26. Hellou J Behavioural. ecotoxicology, an "early warning" signal to assess environmental quality. Environment Science and Pollution Research International. 2011; 18(1):1-11.
27. Herbet DM, Vandyke JM. The toxicity to fish of mixtures of poisons. Annals of Applied Biology. 1964; 53:415-421.
28. Hopkins WA, Snodgrass JW, Staub BP, Jackson BP, Congdon JD. Altered swimming performance of a benthic fish (*Erimyzon sucetta*) exposed to contaminated sediments. Archives of Environmental Contamination and Toxicology. 2003; 44:383-389.
29. Ip YK, Chew SF. Ammonia production, excretion, toxicity, and defense in fish: a review. Front. Physiol. 1; 2010; Article 134.
30. Javed Md. Heavy Contamination of Freshwater fish and Bed F Sediments in the River Ravi Stretch and Relate Tributaries. Pak J of Biol Sci. 2005; 8(10):1337-1341.
31. Jensen FB. Nitrite disrupts multiple physiological functions in; 2003; 135:9-24.
32. Khare S, Singh S. Histopathological lessonsinduced by copper sulphate and lead nitrate in the gills of fresh water fish Nandus. J Ecotoxicol. Environ. Monit; 2002; 12:105-111**.**
33. Kori-Siakpere O, Ubogu EO. Sublethal haematological effects of zinc on the freshwater fish, *Heteroclarias* sp. (Osteichthyes: Clariidae). African Journal of Biotechnology, 2008; 7(12):2068-2073.
34. Lari E, Pyle G, Rainbow trout (*Oncorhynchus mykiss*) detection, avoidance, and chemosensory effects of oil sands process-affected water. Environmental Pollution; 2017; 223:40-46.
35. Little EE, Archeski RD, Flerov B, Kozlovskaya A. Behavioral indicators of sublethal toxicity in rainbow trout. Archives of Environmental Contamination and Toxicology. 1990; 19:380-385.
36. Little EE, Finger SE. Swimming behavoiur as an indicator of sublethal toxicity in fish. Environmental Toxicology and Chemistry; 1990; 9:13-19.
37. Loigu E. Evaluation of the impact of non-point source pollution on the chemical composition on water in small streams and measures for the enhancement of water quality. In: Laikari H (ed) River basin management-V; Proc IAWPRC. Pergamon, 1989, 212-218
38. Mason CF. Biology of Freshwater Pollution. 3rd Edition, Longman, United Kingdom, 1996.
39. Mishra AK, Mohanty B. Histopathological Effects of Hexavalent Chromium in the Ovary of a Fresh Water Fish, *Channa punctatus* (Bloch). Bulletin of Environmental Contamination and Toxicology. 2008; 80(6):507-511.

40. Mokhtar MB, Ahmad ZA, Vikneswaran M, Sarva MP. Assessment level of heavy Metals in *Penaeus monodonand Oreochromis mossambicus* spp. In selected Aquaculture ponds of high densities development area. Euro J Sci Res. 2009; 30(3):348-360.
41. Morley NJ. Interactive effects of infectious diseases and pollu-tion in aquatic molluscs. Aquat. Toxicol. 2010; 96:27-36.
42. Murugan SS, Kanippasam R, Poongodi K, Puvaneswari S. Bioaccumulation of zinc in Freshwater fish *Channa punctatus* (Bloch) after chronic exposure. Turkis h Journal of Fisheries and Aquatic Sciences. 2008; 8:55-59.
43. Muthukumaravel K, Paulay MG. Toxic effect of cadmium on the electrophoretic protein patterns of gill and muscle of *Oreochromis mossambicus*. E Journal of Chemistry. 2007; 14(2):284-286.
44. National Academies of Sciences, Engineering, and Medicine, Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. National Academies Press, Washington, DC; 2016.
45. NOAA, Anthropogenic Noise in the Marine Environment. Potential Impacts on The Marine Resources of Stellwagen Bank and Channel Islands National Marine Sanctuaries. National Oceanic and Atmospheric Administration, Washington, DC; 2000.
46. Nsofor CI, Ufodike EBC, Onuoha SO. The bioaccumulation of some heavy metals in some organs of two commercial fish; *Clarias gariepinus* (Burchell) and *Chrysicthys nigrodigitatus* (Lacepede) from River Niger, Onitsha shelf, Anambra State, Nigeria. Journal of Aquatic Sciences; 2007; 22(1):33-38.
47. Nwani CD, Nwoye VC, Afiukwa JN, Eyo JE. Assessment of heavy metal concentrations in the tissues (gills and muscles) of six commercially important freshwater fish species of Anambra River south-east Nigeria. Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 2009; 11(1):7-12.
48. Okoye BCO. Heavy metals and organisms in the Lagos Lagoon. International Journal of Environmental Studies; 1991; 37:285-292.
49. Onuoha GC, Nwadukwe FO, Erondu ES. Comparative toxicity of cadmium to crustacean zooplankton (Copepods and Ostracods). Environment and Ecology; 1996; 14:55-562.
50. Oronsaye JAO. Ultrastructural changes in the kidneys of the stickleback, *Gasterosteus aculeatus* (L.) exposed to dissolved cadmium. Journal of Aquatic Sciences. 2001; 16:53-56.
51. Parveen A, Javed M. Effect of water-borne copper on the growth performance of fish *Catla catla*. International Journal Agricultural Biology. 2010; 12:950-952.
52. Peng C, Zhao X, Liu G. Noise in the sea and its impacts on marine organisms. Int. J Environ. Res. Public Health, 2015; 12:12304-12323.
53. Randall DJ, Tsui TKN. Ammonia toxicity in fish. Marine Pollut. Bull; 2002; 45:17- 23.
54. Rice PJ, Drewes CD, Klubertanz TM, Bradbury SP, Coats JR. Acute toxicity and behavioral effects of chlorpyrifos, permethrin, phenol, strychnine, and 2,4-dinitrophenol to 30-day-old Japanese medaka (*Oryzias latipes*). Environmental Toxicology and Chemistry. 1997; 16(4):696-704.
55. Robinson WS, Ecological correlations and the behavior of individuals. International Journal of Epidemiology; 2009; 38:337-341.
56. Rompala JM, Rutosky FW, Putnam DJ. Concentrations of Environmental Contaminants from Selected Waters in Pennsylvania. United States Fishery and Wildlife Service Report, Pennsylvania, USA, 1984.
57. Rudolph A, Medina P, Urrutia C. Ecotoxicological sedi-ment evaluations in marine aquaculture areas of Chile. Environ. Monit. Assess; 2009; 155:419-429.
58. Sabullah MK, Ahmad SA, Shukor MY, Gansau AJ, Syed MA, Sulaiman MR Heavy metal biomarker: Fish behavior, cellular alteration, enzymatic reaction and proteomics approaches. International Food Research Journal. 2015; 22(2):35-454.
59. Saeidi Mohsen, Jamshidi A. Assessment of heavy metal and oil pollution of sediments of south eastern Caspian Sea using indices. J of Env Stud; 2010; 36:21-38.
60. Schmidt K, Steinberg CEW, Pflugmacher S, Staaks GBO. Xenobiotic substances such as PCB mixtures (Aroclor 1254) and TBT can influence swimming behavior and biotransformation activity (GST) of carp (Cyprinus carpio). Environmental Toxicology. 2004; 19(5):460-470.
61. Scott GR, Sloman KA, The effects of environmental pollutants on complex fish behaviour: integrating behavioural and physiological indicators of toxicity. Aquatic Toxicology; 2004; 68:369-392.
62. Shalaby A, Abbas M. The effects of sublethal doses of cadmium on the disposition of some trace elements and liver function in common carp *Cyprinus carpio* L. Egypt. J Basic. Applied Physiol. 2005; 4:383-395.
63. Sharma M, Chadha P, Borah MK. Fish behaviour and immune response as a potential indicator of stress caused by 4-nonylphenol. American Journal of Biosciences. 2015; 3(6):278-283.
64. Suresh A, Sivatamakrishna B, Radhakishnniah K. Effect of lethal and sublethal concentrations of cadmium on energetics in the gills of fry and fingerlings of *Cyprinus carpio*. Bulletin of Environmental Toxicology. 1993; 5:920 – 926.
65. USEPA Assessment and Control of Bio concentrable Contaminants in Surface Waters. Office of Health and Environmental Assessment, US Environmental Protection Agency, Cincinnati, Ohio, USA, 1991.
66. Vinodhini R, Narayanan M. Bioaccumulation of heavy metals in organs of fresh water fish *Cyprino carpio* (common carp). International Journal of Environmental Science and Technology. 2008; 5(2):179-182.
67. Voegborlo RB, Methnani AME, Abedin MZ. Mercury, cadmium and lead content of canned Tuna fish. Food Chemistry. 1999; 69(4):341-345.
68. Vutukuru SS. Acute effects of hexavalent chromium on survival, oxygen consumption, haematological parameters and some biochemical profiles of the Indian Major carp, *Labeo rohita*. International Journal of Environmental Research and Public Health. 2005; 2(3):456-462.
69. Weatherly AH, Lake PS, Rogers SC. Zinc pollution and ecology of freshwater Environment. In: Nriagu J. O. (Ed.) Zincin the Environment, Part 1: Ecological Cycling, Wiley Interscience, New York, USA, 1980.
70. Wicks BJ, Randall DJ. The effect of feeding and fasting on ammonia toxicity in juvenile rainbow trout, Oncorhynchus mykiss. Aquat. Toxicol. 2002; 59:71-82.
71. Wlasow TK, Demska-Zakes P, Gomulka P. Various

aspects of piscine toxicology, Interdiscip Toxicol. 2010; 3:100-104.

72. Woodward DE, Brumbaugh WG, Deloney AJ, Little EE, Smith CE. Effect of contaminant metals on fish in the Clark Fork River in Montana. Transactions of American Fisheries Societ. 1994; 123:51-62.