

AGRICULTURE AND AQUACULTURE: THREATS TO BIODIVERSITY

Abstract

Agriculture and aquaculture form a major source of income in the Asian countries. Along with the benefits provided by both sectors to mankind, many adverse consequences are also produced to the ecological functions and services. Methane emissions from cattle rearing, eutrophication due to point and nonpoint sources of drainages, pesticides, antibiotics, escapement of introduced, exotic or genetically modified organisms etc. are included in the negative consequences. In all cases, freshwater and marine aquatic organisms are affected by bioaccumulation and biomagnification and will directly affect the biological functions of the organisms which ultimately affect mankind. Therefore, it is required strict guidelines for the proper aquaculture and agriculture practices will have a positive impact on biodiversity.

Keywords: Threats, Biodiversity, Agriculture, Aquaculture, Eutrophication

Authors

Saritha Sadasivan

Assistant Professor
School of Fisheries
Centurion University of Technology and Management
Paralakhemundi, Odisha, India.

Prachi Bagde

Assistant Professor
School of Fisheries
Centurion University of Technology and Management
Paralakhemundi, Odisha, India.

Iffat Jahan

Assistant Professor
School of Fisheries
Centurion University of Technology and Management
Paralakhemundi, Odisha, India.

I. INTRODUCTION

Agriculture is the major source of income in many Asian countries. Around the world, more than 50% of the people are employed in the agriculture sector. Rice production is dominating with the range of other crops, plantations and livestock, and mixed crops-livestock farming methods are also widespread. Seeds, fertilizer, machinery, and labour are crucial inputs. Crops, wool, dairy, and rooster merchandise are the various system's outputs. However, there is still lot of poverty and starvation in some rural regions indicating the problems in productivity in this sector. It is challenging for millions of small-scale farmers to provide food for their families, much less turn a profit from their labour, due to water shortages, climate change, and fragmented land holdings.

Fish and seafood farming, or aquaculture, is a widely recognized strategy for providing protein for human consumption. Fish is ingested as a source of protein and has important nutritional components like omega-3 fatty acids which are good for the heart and brain. There are many methods used by mankind to raise fish in natural water bodies as well as manmade ponds and raceways. Many innovative methods like biofloc aquaculture, Recirculatory aquaculture, aquaponics etc. helps to reduce the negative impacts of aquaculture to the natural ecosystem and biodiversity.

II. AGRICULTURE

In the world, India's population is still mostly reliant on agriculture, which is the backbone of the Indian economy. More than 56.0% of the main workers in India are engaged in agriculture and allied activities. This makes India stand second in producing rice, wheat and dry fruits in the world, contributing sixteen per cent (16%) of the total GDP and ten per cent (10%) of total exports. Aside from the advantages, agriculture has certain unfavourable effects.

III. EFFECT OF AGRICULTURE ON COASTAL ECOSYSTEM

The water quality of the coastal water deteriorates due to polluted runoff from various land-based activities. The runoff from nonpoint sources enters the river ecosystem, which eventually gets entry into coastal waters. Urban and agricultural runoff is the main contributors to organic and mineral materials suspended in coastal waterways, as well as inorganic nutrients that cause eutrophication (such as additional loads of N and P). Based on various studies regarding land-derived pollution and water quality and the susceptibility of the coastal zone to watersheds found that Point sources and non-point sources are the two main categories of sources from which pollutants reach the aquatic environment.

Point Source and Non-Point Source: A single observable source is denoted as a point source of pollution. An example of a point source is a drain or a pipe that is an isolated, and distinguishable source of pollution which directly opens to a water body. In this sense, the industrial waste that is routinely disposed of by being dumped into rivers and the ocean directly is considered as point source pollution. The non-point source of pollution, also known as "diffuse" pollution, are those inputs and effects that spread over a large region and are difficult to assign to a single source. This comprises sewage discharges from on-site

sewage disposal systems (such as septic tanks), runoff from agricultural and forestry land and stormwater run-off from metropolitan areas.

Non-point source of pollution, or polluted runoff, is one of the greatest threats to the coastal waters. An increase in contaminated runoff has been associated with a decline in the variety and number of aquatic species, including several ecological and economically significant fish species. In addition to that, non-point source pollution has contributed to the deteriorating effect on coral reefs, seagrass beds and the occurrence of algal blooms including harmful algal blooms. Along with this many shellfish beds and swimming beach closures can be recognised due to pollution runoff.

The run-off remnants of insecticides and pesticides used in agriculture land find the way and drain to the waterbodies contaminating coastal waters and having a negative effect on the aquatic organisms, whether they are cultivated or not, as well as the release of methane and ammonia produced contributed to the greenhouse effect. These two are the main agricultural contributors among many to the pollution of coastal waters. The rich nutrients present in this runoff as well as runoff from silage and slurry manure, use of fertilizers develop red tide or may stimulate high algal growth or harmful algal blooms (HAB) or eutrophication. These HABs produce toxins that can kill fish, shellfish, animals and birds. The impact of eutrophication ranges from altered species composition at mild eutrophication to enhanced growth of benthos, fish, and phytoplankton.

The best concentration and effects of maximum contaminants could be expected to occur in coastal areas and estuaries then goes to the ocean with the aid of using flows from the encompassing land specifically through rivers [1]. Then these contaminants are usually diluted and widely dispersed in the sea. Since maximum contaminants input the ocean with the aid of using flows from the encompassing land, specifically through rivers, the best concentrations are regularly discovered in the seabed where these materials settle with elevated concentration [1].

Areas like estuaries and lagoons have the risk of double, where these areas are close to direct sources of pollution [1]. These pollutants may be not readily degradable, or not at all degradable which is toxic to living organisms, and bio-available. An essential component of this phenomenon is the accessibility of chemicals that have been absorbed by sediment to organisms. A chemical's exterior accessibility to an organism is known as bioavailability in the aquatic environment.

IV. AGRICULTURAL WASTES AND ITS EFFECTS

The quantities and types of waste produced in agriculture vary, which include packaging materials, plastics, silage, redundant machinery, tyres, net wraps, oil, batteries, old fencing, scrap materials and building wastes. Along with this, other less common wastes include unused pesticides, veterinary medicines, and horticultural wastes and spent sheep dip.

- 1. Nutrient Content in Agricultural Wastes:** Manure is an important valuable outcome produced in livestock and poultry operations, as well as from agriculture. These manures are spin-offs containing many plant vitamins, minerals, nutrients and many natural matters [2]. Animal manure may be an asset in preference to legal responsibility for

manufacturers while efficiently controlled and nicely used on area crops. To improve the physicochemical properties of soil, the micro and macro nutrients present in the manure will help and it also increases the nutrient retention capacity, increase the infiltration of water, reduces wind and water erosion and promote the growth of beneficial organisms [2]. Knowledge on capturing the benefits of our resources captures good nutrient management.

2. **Nutrient Contents in Manure:** Manure contains a high concentration of nutrients, including trace elements required for the growth of crop. The price of manure fluctuates with the nutrient content, method of collection and mode of storage. Biochemical analysis of manure should be done or obtained before applying to the fields, and this can be used in place of fertilizer for agriculture or crop growth, reducing the need for fertilizers [2].
3. **Nutrients in Manure and Commercial Fertilizers:** Normally plant vitamins in business fertilizers are water soluble and advantages the easily plant uptake. Some vitamins are in their organic form and some can be lost during applications, because of this not all of the vitamins present in manure are available to plants for the whole 12 months after the treatment [2]. Depending on the type of manure and the method of application, the availability of nutrients varies from 30-80 percent. In the effluent most of the nitrogen is in the form of ammonia and or ammonium is more likely to be lost by volatilization when being stored and applied to the ground [2]. The time of application of manure also affects the quantity of nutrients available to the crop. It is expected that the availability would increase when manure application and crop nutrient uptake are in sync [2]. Manure availability of phosphate and potassium is thought to be comparable to that of commercial fertilizer. The phosphorus and potassium in the manure are in inorganic form and 90 per cent of this form is thought to be available in the first year of application and remaining in the subsequent years. Manure, on the other hand, contains organic carbon, which is essential for sustaining soil health, including cation exchange capability, soil tilth, and water retention capacity.

V. BIO-CONCENTRATION (BIOACCUMULATION) AND BIOMAGNIFICATION

It is important to know or to understand the bioconcentration of contaminants in various organs in an organism. The term "conservative pollutants" refers to substances like certain pesticides, industrial chemicals like PCBs, and heavy metals like tin, lead, and mercury. Conservative contaminants cannot be degraded and thus accumulate in the soil or marine environment. Bioaccumulation is the ratio of the concentration of compounds in the organisms and the concentration in the surrounding aquatic ecosystem. When contaminants are present in the water body, it will build up in the tissues of organisms over time. The concentration in the organism's tissue depends on the stability of the chemicals as well as how it will build up in the body fat, ie., lipophilicity. These accumulated contaminants subsequently risk the consumer organisms including humans.

Conservative contaminants are not metabolized. As a result, when a predator consumes a polluting creature, the pollutants are simply transferred to the predator and start accumulating in its tissues. An organism may accumulate very high quantities of the pollutant in its tissues by devouring a large number of prey. The pollutant concentrations in the top predator could become quite high and occasionally fatal as the process moves up the food

chain. This phenomenon is known as biomagnification [3]. This indicated a higher concentration of contaminants present in the organisms than in its diet. It has to do with the bioavailability, as well as how quickly they can metabolise and excrete those contaminants [3]. The degree of effects of each contaminant varies due to the fact that they can be available in different forms and different concentrations for uptake [3].

VI. ORGANIC SYNTHETIC SUBSTANCES

Persistent Organic compounds (POPs) are organic compounds and as such exhibit high lipid solubility, but still, there are almost limitless possibilities to combine new substances. Its effects affect the metabolic and physiological activities of both marine vertebrates and invertebrates [4]. Through bioaccumulation, these compounds affect and influence the organism and the environment negatively, which reconcentrates these chemical compounds to potentially hazardous levels [5]. PBTs (Persistent Bioaccumulative, and Toxic) or TOMPs (Toxic Organic Micropollutants) are the other terms classed under POPs.

Pesticides, including chlorinated pesticides like DDT and DDE, Polycyclic Aromatic Hydrocarbons, Hexanecyclo Hexane, and Organometallics such as tributyltin are more reactive and susceptible to chemical and biochemical transformation [5]. There are 209 congeners of Poly Chloro Biphenyls, each with distinct properties, complicating both analysis and effect studies [6]. PCBs are frequently detected in fish liver, seal blubber, hen eggs and even human fat. The effects of organochlorine on marine organisms are mainly related to impaired reproductive ability and other metabolic disorders [6]. The concentration of octachlorostyrene (OCSs) might be interpreted as evidence of incomplete combustion, which would accumulate chlorinated hydrocarbons in marine organisms [6]. Organometallic substances like tributyltin, have been widely utilised as antifouling agents but are now prohibited in many countries due to their imposex effect. Imposex is the condition in which a change in sexual characteristics in invertebrates, such as growth of female gastropods instance.

The vulnerability of various organisms to contaminants varies to diverse degrees. Age, sex, the availability of food, reproductive health, and genetic makeup can all affect how sensitive an animal is to a certain toxin, even within the same species. The same species' young larval forms are typically significantly more sensitive than the adults. It is now generally known that the chemicals released into the environment have the potential to alter the well-being of the ecosystem both in ecosystem functions and services. The main interference is in the endocrine structures, particularly making vulnerable in the reproductive hormone-receptor structure of the organisms. Infertility, changes in sperm counts, genital tract deformities, increased frequency in mammary, prostate, and testicular tumour and the feminization of males of many species in many vertebrates and altered reproductive habits have been reported.

VII. AQUACULTURE

Aquaculture also called aquafarming is the farming of aquatic organisms and aquatic plants in controlled conditions for food and other purposes. About 13 per cent of the world's fish and other aquatic products comes from aquaculture and its diversity in production depends on the wide diversity of aquatic organisms for food and the maintenance of water

quality [7]. Still, this practice also has negative impacts on the aquatic ecosystem by means of eutrophication, accidental introduction of alien species into the natural ecosystem, salination and conversion of land to something else. Even in integrated systems were meant for maximum utilization of waste, but still practically better to consider wastes as “resources out of place”.

- 1. Positive Impacts of Aquaculture:** Aquaculture is also an important economic activity. Providing employment to 14.5 million people in fisheries activities for their livelihood [7]. This helps to compensate for the low growth rate of Capture fisheries. Contributing 0.83% to the total GDP and 4.73% to the Agricultural GDP (DADF-2020). The culture of molluscs and seaweed can counteract nutrient enrichment. Some other positive benefits of aquaculture are; a) Production of fish can lessen stress on wild stocks, which can also additionally already be overexploited; b) Stocking organisms from aquaculture structures might also additionally assist in decorating depleted shares with constrained reproductive success; c) waste and other effluents from aquaculture can enhance production and abundance of other aquatic organisms in nearby environment; d) destructive land use pattern, such as some unused slash and burn agricultural land can be used as aquaculture ponds which helps to generate additional income, reduce poverty and enhance the socio-economic wellbeing [8].
- 2. Effects of Aquaculture on Biodiversity:** The major problems include a) threats of cultured aquatic organisms to the natural waterbody and their potential hazards to invasive species; b) the nutrient-rich aquaculture wastes and effluents to the surrounding water may lead to eutrophication and change in the fauna in receiving water; c) conversion of sensitive backwaters for aquaculture purposes; d) Overexploitation of aquatic resources for aquaculture and other purposes; e) transfer of diseases to the wild stocks; f) Genetic alterations of wild stocks due to the mixing up of escaped organisms; g) Wanton killing; h) usage of antibiotics and hormones.
- 3. Escapement and Genetic Alterations of Wild Stocks:** Altering genotypes of native species is the most negative impact due to the accidental introduction of a new species to the natural waterbody, which has the power to change the entire network of biodiversity. The most favoured characteristics required for an introduced species for aquaculture purpose includes great genetic variability, short generation time, rapid growth and development and early maturation [8]. The most frequent example of invasive species is tilapia brought on by aquaculture, since it has invaded all continents displacing many indigenous species. Although it is difficult to get the data or statistics on the cause of the introduction of tilapia, more than half of the documented introduction of tilapia is purposefully stocked in natural waterbodies by government organizations rather than the result of industrial aquaculture [8]. Escape of aquarium pets to the natural waterbody and establish there are no consequences of aquaculture.

The majority of the species raised in aquaculture are basically natural, but few have undergone selective breeding to achieve the favoured culture characteristics. Certain species underwent hybridization or polyploidy changes. Although genetic problems for escapees may be eliminated by perpetual sterility, there may still be problems with competition between native and domesticated species, even though the number of

escapees or reproduction and generation of young ones would not be possible following the escape.

- 4. Effluents' Effects on Water Quality:** As already mentioned, another major negative impact of aquaculture on biodiversity is the discharge of effluents from the aquaculture system. Agriculture and aquaculture, both produce waste that may be absorbed by natural systems. The importance of aquaculture waste on its capacity effect may be pretty large, hence requiring crucial considerations. Studies have shown that aquaculture discharges have a stronger impact on regional biodiversity especially during greater oligotrophic marine waters.

Freshwater and brackish water aquaculture systems have many more nutrient-loading issues in comparison with marine cage culture. Shrimp farms contaminate the land, surrounding water bodies as well as the groundwater table. In order to exchange the water during culture operation to maintain the water quality, wastes and nutrients from the culture are added to the receiving water. That increases the BOD level in the receiving waterbody. Many studies are evaluating the nutrient load and measures are also suggested for reducing the nutrient loads, but many aquaculture systems in developing countries still discharge untreated water to the natural waterbodies.

The common treatment options for effluents before the discharge include the use of settling ponds to sequester particles, oysters used to remove suspended particles, and seaweeds or other plants used as biofilter to remove excess nutrients. Water released from the ponds is typically of significantly lower quality than the receiving waters, yet occasionally, as a result of remediation procedures used during aquaculture processes, its quality will be higher.

Pollution from aquaculture is a threat to aquaculture itself and the biodiversity in its surroundings. Of course, poor water quality produces poor fish development. This can be overcome by proper feed management and water quality management, especially in intensive aquaculture practices.

- 5. Conversion of Sensitive Land:** This is one of the negative impacts of shrimp culture practices which received much attention. The main fact is that mangroves are destroyed to facilitate brackish water aquaculture practices. When shrimp production intensifies, disease outbreaks and other issues lead to the failure of some aquaculture systems. In such cases ponds may be abandoned and the conversion of mangrove forest into undeveloped land. Another issue is the conversion of land for brackish water aquaculture practices where land is cleared, salt water is brought inland, and as a result, soil gets salinized. It seems that the soil become too salted to allow the altered area to resume its regular productive processes.

In all these concerns, shrimp production has been increasing in many parts of the world including India. Loss of mangroves is substantial which is estimated to be reduced by about 33 per cent. These significant losses have been brought on by coastal development which includes urbanization, agriculture, and aquaculture. Shrimp farming is estimated to be responsible for less than 10 per cent of the global loss of mangroves because the total area of shrimp ponds worldwide is relatively small.

- 6. Inefficient Resource Use:** The use of fish meal and fish oil in fish feed preparation also poses a significant threat. Earlier, fish meal was prepared using bycatch landings. But now fish meal has got increased demand, hence overfishing leads to decreasing biodiversity. Fish meal commonly comes from small pelagics, overfishing of these resources collapses the food web. For this reason, the use of fish meal in aquaculture is considered a negative impact on the industry.

The cost of production of fish feed using fish meal is less, which makes the use of fish meal become more in the aquaculture industry. In addition to this, fish meal is also used in pet food business and cattle nutrition. Aquaculture research and development has to focus more on the alternative of fish meal in aqua feeds like plant proteins and waste products from other operations. The usage of fish meal is well established in the animal feed business, and the elimination of fish meal from aquaculture feeds does not remove it from other uses. It will take a comprehensive effort across all facets of animal feed production to lessen the impact on species used in fish meal production.

- 7. Disease or Parasite Transfer From Captive to Wild Stocks:** Transfer of diseases, especially bacterial, viral and fungal diseases from the culture system to the wild is a serious negative impact of aquaculture. These problems combined with concern about anti-biotic resistance that could develop from the use of antibiotics in culture, have been suspected for a long time but not substantiated.
- 8. Eutrophication:** Eutrophication is due to the excessive nutrient-rich run-off from the land, the receiving water body causes a dense growth of plant life. The high amount of specific nutrients like phosphorus and nitrogen which is necessary for plant growth regulates this process. In freshwater, nitrogen is typically the limiting nutrient, whereas phosphorus is the case in estuaries and salt water. However, the process of eutrophication speeds up when humans release nutrients like phosphate (agriculture: 50%, Industry: 10% and natural erosion: 10%). Excess growth of plants due to eutrophication smothers the organisms present there when they die and begin to decay. That again releases nutrients making the system more vulnerable. The diverse chemical forms of phosphorus and nitrogen are converted into a common or equivalent form to provide a eutrophication indicator.

VIII. UNEP RECOMMENDATIONS TO MINIMISE THE ADVERSE IMPACTS OF AQUACULTURE ON WILD STOCKS

- Closed culture: Provides better control to prevent the escape of organisms
- Sterilization: Helps to reproduction control and avoid direct genetic effects
- Localisation: Site selection, avoid the farm away from the wild population.
- Coastal parks: implementation of protected areas
- Selective fishing practices: to reduce the fishing pressure on wild stock by directing the pressure towards cultured fish
- Transportation restriction: restrict the transportation of live fish and eggs to reduce the spread of exotic genes
- Gene banks: by the establishment of gene bank, counteract the extinction of the local population

- Training: Provide training to workers on basic aquaculture practices to minimize the risk of accidental release of organisms in natural water bodies.

IX. CONCLUSION

Pollution from agricultural runoff is a growing problem worldwide. Aquaculture in coastal areas is also contributing enough problems to the coastal ecosystems that are adversely affecting biodiversity. There is strict enforcement in management measures for the sustainable use of agriculture as well as aquaculture.

For protecting the wild population and their environment, documenting the natural resources and threats to their survival is very important. Many databases are available now providing the basic data regarding the terrestrial and aquatic resources. Policymakers and researchers make use of these available data for further assessment and conservation policies.

REFERENCES

- [1] Ducrotoy, Jean-Paul (2020): Coastal pollution and impacts. Available from http://www.coastalwiki.org/wiki/Coastal_pollution_and_impacts.
- [2] Zhang, H., 2002. Fertilizer nutrients in animal manure. Oklahoma Cooperative Extension Service.
- [3] "Bioaccumulation ." The Gale Encyclopedia of Science. Retrieved June 22, 2023
- [4] T. Zacharia J (2019) Degradation Pathways of Persistent Organic Pollutants (POPs) in the Environment. Persistent Organic Pollutants. IntechOpen. DOI: 10.5772/intechopen.79645.
- [5] Kaoud Hussein, A., 2015. Article review: heavy metals and pesticides in aquaculture: health problems. Eur J Acad Essays, 2(9), pp.15-22.
- [6] Ajidhaslin, S. and Aruna, S. 2022. Contamination of Coastal Environment by Anthropogenic Activities. Vigyan Varta 3(12): 39-44.
- [7] Food and agriculture organization-2020. Aquaculture production (fao.org).
- [8] James S. Diana, Aquaculture Production and Biodiversity Conservation, BioScience, Volume 59, Issue 1, January 2009, Pages 27–38, <https://doi.org/10.1525/bio.2009.59.1.7>