

Open Defecation and Eutrophication in the Niger Delta Region of Nigeria

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Abstract: This article discusses how poor sanitary practice (open defecation) influences the eutrophication of water bodies in the Niger Delta Region. Open defecation is a common practice amongst dweller in the region and this has a far-reaching implication on the natural quality of water of bodies in the area which serves as a primary source of water for domestic use and a mean of livelihood. Human excreta are potential sources of plant nutrients including nitrate and phosphate. Nitrate and phosphate are essential nutrients required for the growth and productivity of plants. Eutrophication is the enrichment of water bodies with nutrients induces excessive growth of macrophytes, algae, and other aquatic plants. Eutrophic nutrients are formed from urea through two chemical processes: hydrolysis and oxidation. While organic materials rich in protein or other nitrogen-rich substrate go through the processes of hydrolysis, acidogenesis, acetogenesis, and oxidation. The increased population of seaweeds creates a hypoxic and anoxic condition in water bodies which consequently causes the death of oxygen sustained organisms. Monitoring and managing water bodies to prevent or limit eutrophication is therefore critical. A variety of management strategies have been proposed by scholars including treatment of effluents to specified limits before discharging into the water bodies and physical harvesting, application of chemicals such as algaecides and flocculants, a biological method using phytoplankton eating organisms and watershed management.

Keywords: Open Defecation, Eutrophication, Water Pollution, Niger Delta, urea, Algae Bloom.

I. INTRODUCTION

Access to proper sanitary facility is fundamental not only for human development but also for the protection of human health and the environment [43] [31]. Sanitation refers to a system that promotes proper disposal of human and animal waste for improving and protecting public and environmental health.

According to a report by WHO and UNICEF, almost a billion people across the globe do not have access to proper sanitary facilities and practice open defecation, majority of whom are rural dwellers in developing countries [92]. In sub-Saharan Africa, many countries are confronted with the challenge of poor sanitary conditions. Sustainable development goal (SDG) regions across the globe saw a decline in the number of open defecators, except for sub-Saharan Africa, where high population growth allegedly led to an increase in open defecation from 204 million to 220 million, and in Oceania, where the practice increased from 1 million to 1.3 million [44].

World Development Indicators in 2016 revealed that in Nigeria, the prevalence of open defecation increased from 24% of the total population in 1990 to 25.1% in 2015 [100].

In a recent report by UNICEF, Nigeria leads in open defecation index globally overtaking India as the country with the highest number of people practicing open defecation. About 47 million Nigerians practice open defecation [91]

Improper sanitary practice like open defecation in Nigeria is most prevalent in rural settlements like the riverine communities in the Niger Delta region of Nigeria. A large population of the residents in the Niger Delta resides along the

coastline where there are little or no basic sanitation facilities. This implies that residents in communities along the coastline defecate on the surface water, while communities located away from the coastline defecate on bare ground in bushes, dark corners and even rivers that pass through their communities [75] [66] Open defecation poses significant threat to the environment and human health. It leads to the pollution of surface water with harmful fecal microorganisms and bacteria. These disease-causing organisms are associated with diarrhea, typhoid fever, cholera, giardiasis, infantile papalysis (poliomyelitis), etc. Open defecation increases the nutrient load of surface water. Nutrients however, are essential for the sustenance of the aquatic ecosystem, extremely high concentrations will lead to excessive growth of aquatic plants in water body leading to algal bloom which eventually leads to the decrease in the concentration of dissolved oxygen required for macro invertebrates, fishes and microorganisms, shortening of life span of the river [71] [30].

A. THE NIGER DELTA REGION

The Niger Delta region is located on the coastal plain of the southern part of Nigeria which is boarded by the Atlantic Ocean. The region lies on the lower reach of the Niger River and is characterized by a dense network of rivulets, streams, creeks, and rivers and consists of several ecological zones, the sandy coastal ridge barrier, brackish and saline mangrove, seasonal and permanent freshwater swamp forest and low land rain forest which serves several socio-economic and political purposes including sources of water for domestic use, fishing, means of transportation, recreation, etc. for the 35 million people living in the region. According to a report by, seventy percent of the dwellers in the region depends on the vast natural water resources as a mean of livelihood. However, the vast natural water resources in the Niger Delta region is threatened by uncontrolled anthropogenic activities including poor sanitary practices, urbanization and industrialization amongst others. These have resulted in the pollution and degradation of the natural water quality [87] [13]. These researchers [75] [76] [4] in their study in the Niger Delta region suggested that open defecation is one of the inadequate sanitary practices in the region.

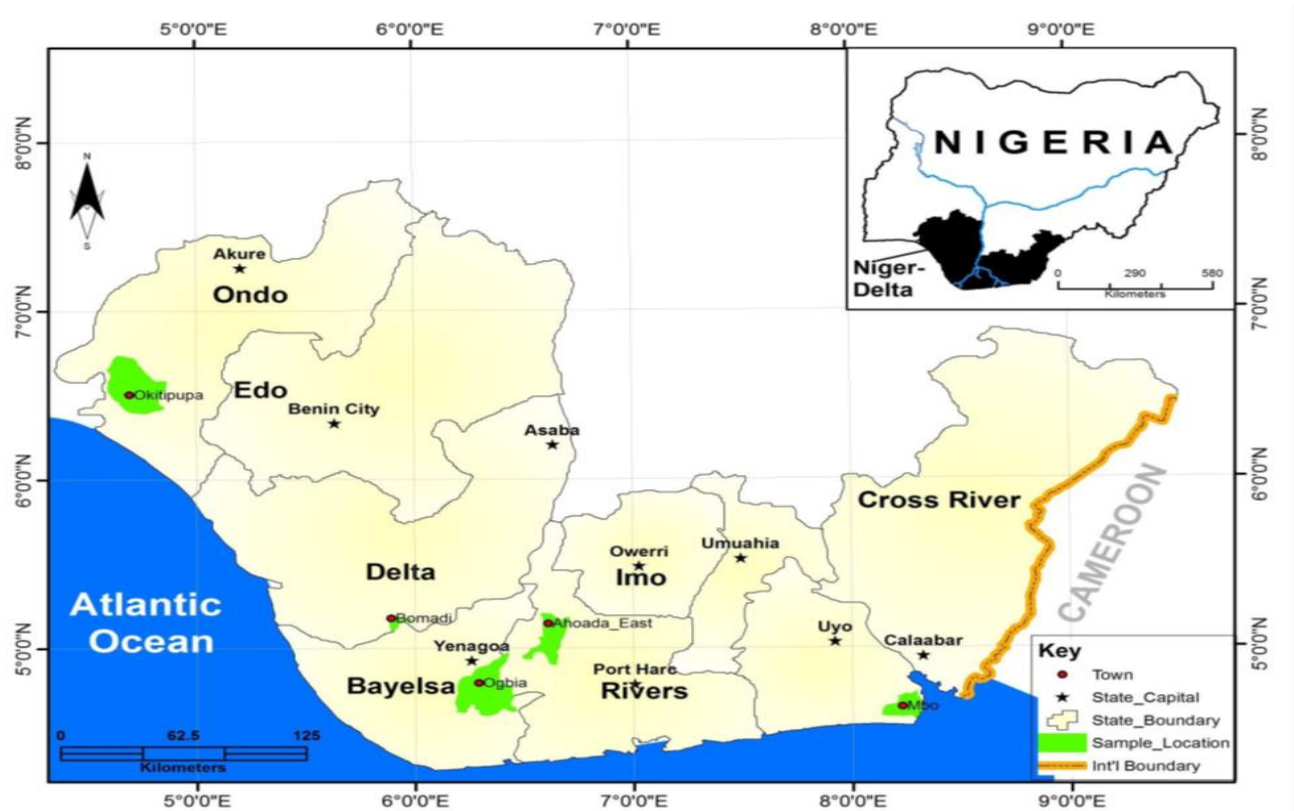


Fig. 1: Map of the Niger Delta region

Source: [26]

II. OPEN DEFECACTION

Open defecation refers to the practice whereby people go out to open fields, roadsides, bushes, periphery of water bodies, or other open spaces rather than using the toilet to defecate [91] [65] [64] [77].



Fig. 2: Open defecation in the Niger Delta region.

Sources: [15].

Several factors have been identified globally to be contributory to the prevalence of open defecation [33] [74]. The views expressed by these researchers are in line with those expressed by these scholars [75] [42] [7] who researched on the open defecation and poor sanitary practice in the region. Some of the identified causes of open defecation in the region includes: high population density, lack of basic toilet facilities, poverty, and the beliefs that defecating in the open is normal and healthy. In some rural communities the practice is tied to the culture, values, and mores of the people.

In most riverine settlement woods and bamboos are used to build open toilets for both men and women just by the shores of rivers. These locally built toilets are done without drainage system, as such, feces are discharge directly into rivers.



Fig. 3: A typical toilet in a riverine community in the Niger Delta region

Source: [70]

A. CONSEQUENCES OF OPEN DEFECATION

Open defecation is a major cause of disease world-wide and also a notable cause of environmental pollution including air, water and land [76] [9] [8].

According to [76] [22] Open defecation contributes to the increasing concentrations and the loading of water bodies with nutrients which are essential for the growth and development of aquatic plants. Aquatic plants serve as the primary producers in the aquatic ecosystem and basis of the food web for many organisms and can grow submerged below, floating on, or up through the water surface. These aquatic plants serve as sources of energy due to their high biomass production. Conversely, overly high nutrient concentrations may create an overabundance of aquatic plants in water bodies, which may, in turn, interfere with natural processes thereby resulting in eutrophication [26] [60].

The relationship between poor sanitary practice and the outbreak and spread of communicable diseases have been documented in literatures [90] [76] [9]. Human excreta are loaded with pathogens and bacteria's which have been implicated in the outbreak and transmission of many infectious diseases including cholera, typhoid, hepatitis, polio, cryptosporidiosis, ascariasis, respiratory diseases and schistosomiasis.

[90] alludes that children and the poor are predominantly affected by human feces-transmitted diseases, and this occurs mostly in developing countries



Fig. 4: Sets of toilets piped directly into a river in a waterside community in Port Harcourt

Source: [15].

B. OPEN DEFECATION AS A SOURCE OF EUTROPHIC NUTRIENTS

Human excreta are potential sources of plant nutrients including nitrate and phosphate [85]. Nitrate and phosphate are essential nutrients required for the growth and productivity of plants [68] [3] [39] [69] [16] [102]. However, when these nutrients get into water body, they support the growth and development of aquatic plants such as macrophytes, algae, etc. [53] [95] amongst other adverse consequences it has on the water body such as bacterial and parasitic pollution of rivers [73] [80] they impact high oxygen demand.

C. COMPOSITION OF HUMAN EXCRETA

Human excreta are comprised of two basic components, urine and feces. feces are made up of 75 percent water and 25 percent solid matter. About 30 percent of the solid matter consists of dead bacteria; about 30 percent consists of indigestible food matter such as cellulose; 10 to 20 percent is cholesterol and other fats; 10 to 20 percent is inorganic substances such as calcium phosphate and iron phosphate; and 2 to 3 percent is protein.

Urine contains nearly 80% of the total nitrogen found in excreta. Urine also contains two-thirds of the excreted phosphorous and potassium. The majority of the carbon excreted, up to 70%, is found in feces.

Table I: Showing components found daily in human excreta.

Elements (g/ppd)	Urine	Faeces	Urine + faeces
Nitrogen	11.0	1.5	12.5
Phosphorous	1.0	0.5	1.5
Potassium	2.5	1.0	3.5
Organic carbon	6.6	21.4	30
Wet weight	1,200	70-140	1,200-1,400
Dry weight	60	35	95

Source: [21].

D. FORMATION OF EUTROPHIC NUTRIENTS FROM HUMAN EXCRETA

Human excreta are composed of water, protein, undigested fats, polysaccharides, bacterial biomass, ash, and undigested food residues. The major elements in feces as a percentage of wet weight are oxygen 74%, hydrogen 10%, carbon 5%, and nitrogen 0.7%, including the hydrogen and oxygen present in the water fraction of the feces [77].

Degradation of organic materials rich in protein or other nitrogen-rich substrate produces ammonia and exists in the form of ammonium ion (NH₄⁺) and NH₃ [98] [97]. Ammonia ion and Ammonium is oxidized to nitrate by Nitrosomonas and Nitrobacter.

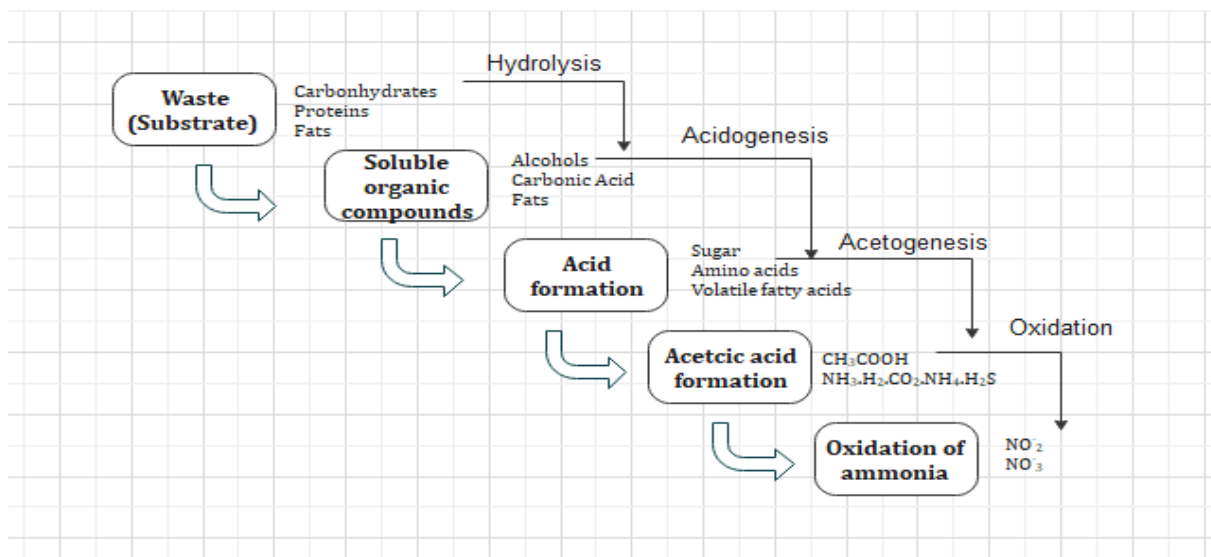


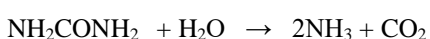
Fig. 5: Formation of nitrate from organic materials.

Source: Author

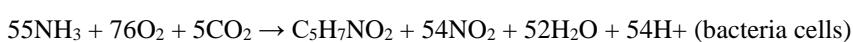
E. FORMATION OF NITRATE FROM UREA

Urine is a liquid by-product of human metabolism in and other animals. Urine is rich in nitrogen such as urea and uric acid. Human excretions contain high concentration of uric acid which is transformed into urea through aerobic decomposition. When mixed with urease present in the fecal material, urea N can quickly be transformed into highly volatile ammonia. [34]

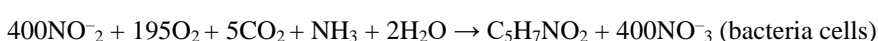
- Hydrolysis of urea



- Oxidation of ammonia by Nitrosomonas.



Oxidation of nitrate by Nitrobacter.



F. EUTROPHICATION OF WATER BODY

Increased concentration of euphoric nutrients in surface water is one most challenging environmental problem confronting the Niger Delta region [28] [84] [16] [48] [18]. Passive attention has been given to this environmental anomaly by both the government and the public. According to [44] [78] [29] [67] [32] [6] eutrophication is the enrichment of surface waters with excess plant nutrients, which leads to enhanced vegetation growth on the surface of the water bodies. [37] explained that many streams and creeks in the region are heavily plagued by eutrophication. This has resulted in the environmental degradation aquatic ecosystems with deteriorating effect on the water quality, increased cases of suspended particles owing to extensive macroalgal blooms, decrease of water clarity, and increase in the rate of precipitation that leads to the destruction of benthic habitat by shading of submerged vegetation.

Eutrophic nutrient results from a variety of natural processes but uncontrolled anthropogenic activities have increased the concentrations of these nutrients on water bodies there causing eutrophication [29] [61] [36]

[16] pointed out that eutrophication of rivers and lakes in the Niger Delta region results from uncontrolled anthropogenic activities including poor waste management practice, poor agricultural practice and poor sanitary practice (open defecation).

[30] argued that although nutrients are essential for maintenance of healthy aquatic life, it's high concentrations in water body will lead to excessive unsightly growth of aquatic plants leading to algal bloom in the river which eventually leads to a dozen adverse effects on the river including reduction in dissolved oxygen required for macro invertebrates, fishes and microorganisms, shortening of life span of the river or lake itself. He further pointed out that, nutrient concentrations in streams and rivers are strongly correlated with human activities which includes point and nonpoint sources. Point sources of nutrients include wastewater effluent (both municipal and industrial) and storm sewer discharge.

Eutrophication of rivers and lakes in the region could be ascribed mainly to uncontrolled anthropogenic activities which have increased the nutrient loads in the water bodies. These activities include: industrial discharge, poor waste management, poor agricultural practices and open defecation. [61] [29]

Open defecation is one of the pronounced causes of eutrophication in the region and this is occasioned by increasing population, unavailability of sanitary facilities and lack of awareness by a great percentage of the dwellers in this region. Open defecation has increased the nutrient loads of water bodies which results in eutrophication.



Fig. 6: A typical river in the Niger Delta region

Source: Author

G. EFFECTS OF EUTROPHICATION ON THE AQUATIC ECOSYSTEM

Eutrophication possesses a serious threat to the aquatic ecosystem [12] [26] [29] [6] [94] [52]

[49] stated that the increased population of seaweeds creates a hypoxic and anoxic condition in water bodies which consequently causes the death of oxygen sustained organisms. Eutrophication unbalances the physical, chemical, and biological characteristics of water bodies.

[24] reported that nitrates are hazardous to human health especially to the vulnerable groups like infants, pregnant women and adults with low stomach acidity or people with a certain enzyme deficiency. Ingesting water with high nitrate concentration causes methemoglobinemia, or “blue baby syndrome,” as the ingested nitrates are converted to nitrites in the body. This reduces the oxygen-carrying capacity of the blood, and severe cases result in brain damage or death [99] Prolonged intake of high nitrates can result in gastric distress in humans and has been shown to cause cancer in test animals.

[29] in his study explained that increased population of aquatic plants causes disturbances of the aquatic ecosystem. It results in the decrease in the amount of silica and increase turbidity of the water bodies. He further explained that nitrate and phosphate are primary causes of eutrophication. Eutrophication affects aesthetics on lakes, rivers and results in odor and appearance problems. The presence of high algal biomass occurring from eutrophication of the shallow tropical African reservoirs will jeopardize the effective functions of the reservoir in providing domestic and industrial water supply, fish production, irrigation, recreation as well as loss of biodiversity and other socio-economic functions of the reservoir. [30] in his study observed that nutrient enrichment leads to excessive growth of primary producers as well as heterotrophic bacteria and fungi, which increases the metabolic activities of stream water leading to a depletion of dissolved oxygen.

[58] hinted that uncontrolled algal biomass resulting from eutrophication in shallow rivers and water bodies can jeopardize the effective functions of such water body in providing water for domestic and industrial purposes, irrigation, fish production, loss of biodiversity, disruption in food web interactions and recreation, as well as the loss of biodiversity and other socio-economic benefits.

[28] in their study concluded that poor sanitary such as the deposition of sewage water bodies in results in the contamination of water bodies with water borne diseases. They further stated that some of the common diseases associated with water pollution include Plesiomonas infection caused by Plesiomonas shigelloides, Typhoid fever caused by Typhus, Cholera caused by vibrio (bacteria), Acute gastroenteritis caused by Norwalk-Type virus and Rotaviruses (viruses) and Toxoplasmosis caused by Toxoplasma gondii, Giardiasis caused by Gardia (protozoans) among other diseases.

[23] in their study titled “Macrophytes in Niger Delta Inland Waters “argued that most problems with macrophytes arise when growth becomes too dense. The floating mat of vegetation of macrophytes in the aquatic environment covers available sunlight from the water surface, which results in low production of natural fish thus resulting in overall low fish productivity. These invasive aquatic macrophytes affect biodiversity as well as water quality. Submerged species can also spoil the gravel spawning beds of some fish (Salmonids) and high densities of photosynthesizing macrophytes are capable of causing large fluctuations in oxygen; this can stress many fish species. Similarly, fish mortality may occur when photosynthesis does not exceed respiration thereby resulting in oxygen depletion. Emergent plants and submerged macrophytes can prevent access and also hinder navigation in water crafts transportation route and maybe detrimental to hydroelectric facilities. This view collaborates the ones expressed by [37] in their study in the Niger Delta region.

[63] pointed out that over population of rivers and lakes with aquatic plants reduces the aesthetic quality of water for recreational activities, like swimming, boating, and picnic.

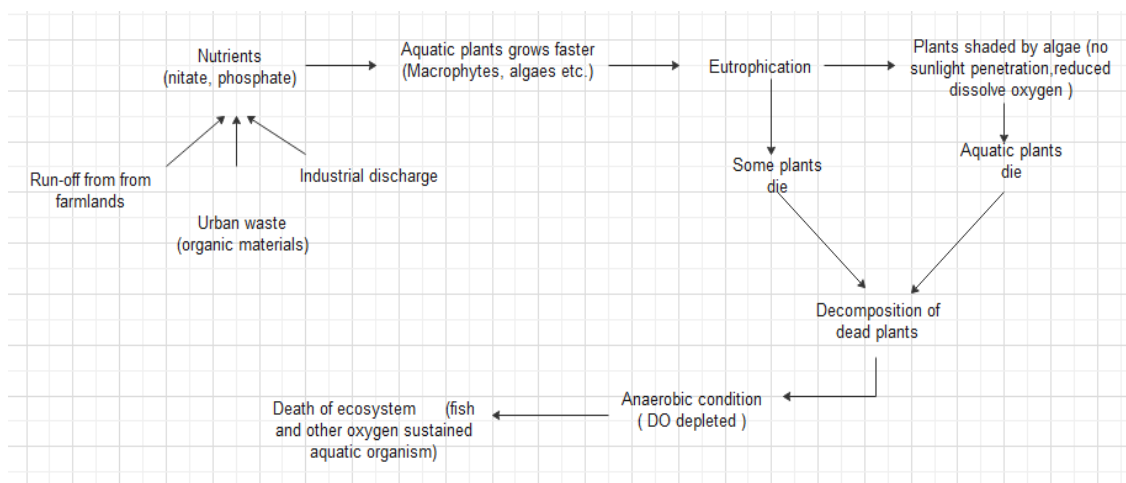


Fig. 7: Impact of nutrients on the aquatic ecosystem.

Source: Author

H. MANAGING EUTROPHICATION IN SURFACE WATER

Monitoring and managing water bodies to prevent or limit eutrophication is critical to achieving balance in the aquatic ecosystem and controlling the excessive invasion of these plants [23] [96] [41] [45]. A variety of management strategies have been proposed by scholars [38] [54] [46] [47].

Point sources of eutrophic nutrients can be managed by active monitoring to ensuring discharged effluents meet the specific standard set by regulatory bodies. While non-point sources could be managed by a variety of approaches including watershed management and protection, physical and chemical methods, and biological methods [57] [17] [96] [20].

i. physical and chemical strategy

Harvesting, destratification, and sediment dredging are physical methods that can be employed for the management of eutrophication [19] [10] [1] [103] [59] [104].

a. Mechanical harvesting

Harvesting entails using mechanical devices to weed out these aquatic plants from the surfaces of rivers. The mechanical harvesters utilize cutters and conveyors to pull aquatic plants from the water and onto the bed of the equipment.

b. Destratification

Destratification is the introduction of nutrient and oxygen-rich waters from the surface down to the hypolimnion using an axial flow propeller pump. This is to enhance the oxidation of either a deoxygenated hypolimnion or the entire water body and/or inhibition of phytoplankton growth.

c. Application Algaecide

Application of algicides and other chemicals such as simazine, flocculants, and copper sulfate has been effective in controlling excessive algal growths in rivers. These chemicals are effective and work rapidly but there are concerns that algaecides may pose a threat to humans as well and have detrimental impacts to lake and reservoir ecosystems [96] [40] [89]

ii. biological method

In this approach organisms are biological engineered to enhance the removal of aquatic plants or inhibit conditions that support their growth. This method relies on food chain manipulation by maintaining low feeding pressure on zooplankton by fish, so that large species of zooplankton predominate, that are capable to keep phytoplankton under control [23] [83] [101].

Some common biological treatments are:

a. Aquatic plants: The introducing of some desired species of macrophytes has the tendency of getting rid of the species which constitute nuisance in the aquatic environment. However, native macrophytes are usually good but because they have more checks and balances with the local environment.

b. Plant eating fish: The introduction of macrophytes eating fish or herbivores can assist in limiting macrophyte growth. Example Grass carp are being used to help control aquatic vegetation. They are bred to be sterile in order to inhibit reproduction in the pond and will eat vegetation in the pond. Chinese Grass carp will consume large quantities of aquatic macrophytes in the right conditions. One concern about the use of fish as a control method is that nutrients are added by their excrement [35] [86] [51] [54].

c. Bacteria: Macrophyte growth can be controlled with the use of bacteria and fungi. Certain varieties of bacteria and fungi live on various macrophytes and can be used to selectively control aquatic vegetation. When the bacteria and fungi is introduced the aquatic macrophyte will die from the and the more desirable plants will be unharmed. The advantage of this method, aside from very low cost, is that it is fully natural, with no chemicals or machinery required; the only means used is manpower. [72]

III. WATERSHED MANAGEMENT

Watershed is the area of land that catches rainwater and drains run-off and stormwater to a common waterway such as a stream, river, lake, or wetland.

Rivers and lakes are subjected to discharges originating from different sources both point and non-point sources. Nutrients like nitrogen and phosphorus in high concentrations distort and disrupt aquatic ecosystems by overfeeding [11]. Proper management of the watershed would help filter contaminants carried by run-off and stormwater before they are discharged into the rivers or lakes thereby reducing the volume of contaminants reaching the rivers. [14] [88].

IV. CONCLUSION

Open defecation is a practice that should be discouraged by providing adequate sanitary facilities and enlighten the people on the danger it possesses to the environment and human health. Open defecation amongst other adverse effects leads to eutrophication of rivers and lakes. Eutrophication is one of the most widespread problems bedeviling the aquatic ecosystem. Eutrophication jeopardizes the effective functions of a water body in providing water for domestic and industrial purposes, irrigation, fish production, loss of biodiversity, disruption in food web interactions, and recreation, as well as the loss of biodiversity and other socio-economic benefits.

For the effective management of nutrient load into water bodies, both point and non-point sources of pollution must be taken into recognition and controlled. The control of erosion and run-off into water bodies remains a proactive remains strategy for curbing eutrophication. In a situation where the water body is impacted already other management options like the use of chemicals, physical harvesting, or biological method could be adopted. However, these management options are not without adverse consequences to both the aquatic ecosystem and humans which must be carefully studied before adopting a strategy.

ABBREVIATIONS (NOMENCLATURE)

WHO	World Health Organisation
UNICEF	United Nation International Children Education Fund
SDG	Sustainable Development Goal
NPC	National population Commission
UNDP	United Nation Development Programme

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