Review Article

Evaluating the Influence of Sewage Pollution on Pond Water Quality and Ecosystem Health

ABSTRACT

This chapter reviews the impact of sewage waste contamination on pond water, focusing on physico-chemical and biological parameters. Historical studies highlight early research on water quality and its effects on aquatic life, with significant work from California and England. Recent findings reveal that pond water often exceeds permissible limits for parameters such as pH, BOD, COD, and TDS, necessitating treatment or dilution. Studies on phytoplankton demonstrate their role in nutrient recovery and wastewater treatment, while heavy metal contamination poses risks to microbial activity and aquatic health. Additionally, ecological risk assessments of urban stormwater ponds emphasize their role in managing urban runoff but also underscore the need for effective pollution control strategies.

Keywords: waste contamination, pollution, nutrient recovery, wastewater treatment

INTRODUCTION

"Water supports life on earth and around which the entire fabric of life is woven. Ponds, as sources of water, are of fundamental importance to man. However, ponds may have been a natural water sources exploited by man at different time to meet different needs, or may have been created for a multitude of different purpose e.g. domestic or agricultural use, for transport, defense, ritual or industrial use, social aggrandizement, swimming, fish farming or the creation of the picturesque" (Ress, 1997; Narayan *et al.*, 2007; Bishnoi and Malik, 2008).

"The major problems affecting standing water bodies have been recognized for at least two decades, but their quantification and classification of environmental managers has proved elusive. The Indian environment managers/researchers has recently described the condition of Indian freshwater resources and their management as a prominent environmental problem with nutrition enrichment, acidification and domestic waste, sewage, agricultural and industrial effluents contamination by toxic substances identified as major impacts" (Sachidanandamurthy and Yajurvedi, 2006; Parashar *et al.*, 2008; Shekhar *et al.*, 2008; Senthilkumar and Sivakumar, 2008; Laskar and Gupta, 2009). The requirement of water to all

living organisms, from micro-organisms to man, is a serious challenge today because all water resources are polluted due to unplanned urbanization and industrialization.

"Safe drinking water and adequate environmental sanitation are preconditions for health and for success in the fight against poverty, hunger and child deaths. Worldwide in 1995, contaminated water and food caused more than 3 million deaths, of which more than 80% were among children under age five" (WHO 1996). Globally, the World Health Organization (WHO) estimates that "1.8 million people die each year from diarrhoeal diseases. Faechem (1980) reported that at least one and a half thousand million people worldwide used polluted water. This problem is more acute in developing countries where higher incidence of water-borne diseases is reported".

"In India, more than 70% of the epidemic emergencies are either water borne or are water related" (Khera, *et al* 1996). Among waterborne diseases of bacterial origin typhoid, bacillary dysentery and diarrhoea are common in Bangladesh. Although a substantial amount of work has been carried out on common water borne pathogens in Bangladesh, unfortunately a little information is available.

"The water quality of small water bodies, particularly in the urban areas of India is under the influence of the growing population and development. Development results in migration of rural population to urban areas. It is easy for these migrants to settle on the open areas nearby ponds, lakes, canals, etc. where solid and fecal waste is being dumped into water body. Added to this, the other sources of pollution of small water bodies are agricultural runoff, industrial waste and garbage etc. These wastes increase pollutants in terms of nutrients, organic matter and toxic substances in the water bodies and disturb its ecosystem" (Faechem, 1980).

"The World Health Organization (WHO) reported that nearly half of the population in developing countries suffers from health problems associated with lack of drinking water or with microbiologically contaminated water. Groundwater is an important source of drinking water and its quality is currently threatened by the combination of chemical pollution and microbiological contamination, especially microbes of sewage origin. High incidence of diarrhea, helmenthiasis, trachoma and the overall high mortality rates are associated with poor environmental sanitation. Sanitation with good hygiene, acts as a fundamental 'Primary barrier' by ensuring that fecal matter is disposed of safely, and does not spread in the environment. Once in the environment, however, here are many ways in which infected fecal

matter can be spread. Currently, about 20% of the world's population lacks access to safe drinking water, and more than 5 million people die annually from 1844 illness associated with safe drinking water or inadequate sanitation" (Joydev *et al.*, 2010). "The World Health Organization estimated that up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water. Approximately three out of five persons in developing countries do not have access of safe drinking water and only about one in four has any kind of sanitary facilities. The World Health Organization (WHO) reported that nearly half of the population in developing countries suffers from health problems associated with lack of drinking water or with microbiologically contaminated water" (Joydev et al., 2010).

In Tamil Nadu, Thanjavur being the foremost district of the Cauvery delta occupies an important position in the agricultural map of Tamil Nadu. Since its formation, the district is called as the rice bowl of Tamil Nadu. The District is bounded on the north by the Coleroon which separates it from Perambalur and Tiruchirapalli district, and on the East it is bounded by the Thiruvarur and Nagapattinam districts and on the South by the Palk Strait and Pudukottai district and on the West by Pudukottai and Tiruchirapalli districts.

"Pattukkottai is a town and a municipality in Thanjavur district in the Indian state of Tamil Nadu. Pattukkottai is located at 10.43° N 79.32° E. It is a peaceful town situated in the Cauvery delta and comes under the Tropical Dry Evergreen Forest region. It receives maximum rainfall during winter months as it lies along the Coromandel Coast of South India. It has an average elevation of 5 metres (16 feet) and city lies in Thanjavur District in the State of Tamil Nadu, It is one of the Divisional Head Quarters of all Departments, 48 Km from Thanjavur" (Joydev et al., 2010).

"As of 2001 India census GR India, Pattukkottai had a population of 65,453. Males constitute 50% of the population and females 50%. Pattukkottai has an average literacy rate of 74%, higher than the national average of 59.5%: male literacy is 80% and female literacy is 69%. In Pattukkottai, 11% of the population is under 6 years of age. Agriculture, using water from the Kaveri River for irrigation, is the mainstay of the area, though the town hosts a number of other businesses. Paddy and Coconut are the major crops. In Tamil Nadu after Pollachi, coconut cultivation has been extensively done in Pattukkottai surroundings" (Joydev et al., 2010).

"In Pattukottai, as like any other sub urban town, five ponds are mostly affected by sewage water and agricultural runoff. All ponds are surrounded by temples, agricultural fields, and human settlements. There is a solid waste dumping site on fringe of the ponds. Now this study area is merged in the Pattukkottai Municipal Corporation limits. The upper catchment area of the ponds includes rural and agricultural areas. The inlet and outlet of the ponds are open. The runoff in the monsoon and sewage from the area are disposed into the ponds, as there is no proper sewage collection and disposal system. The overflow from the pond flows into nearby open channel and is ultimately disposed into river without any treatment. Locals are not using the pond water for drinking, washing or bathing and cattle washing. Pond is totally infested with *Eichhornia* sp" (Joydev et al., 2010). The main body of the pond remains full of water and is perennial. Apart from *Eicchornia* sp, there is tremendous load of phytoplankton in the pond due to the addition of organic matter. Though there are programmes on algal blooms throughout the country, research is not ample in these areas.

WATER QUALITY

The first study of water quality of fish pond in India was probably done by Sewell (1927) when he studied the mortality of fish in the Museum tank in Calcutta. Pruthi (1932) also studied in detail the water conditions of the same tank in connection with mortality of fishes. Since then a number of workers have studied the Physico-chemical conditions of inland waters either in connection with fish mortality or as part of general hydrological survey.

"After examining some of the literature in this area, it became readily apparent that certain groups or States had conducted and are still conducting most of the research. Without doubt since the early 1950s there has been more activity in the State of California in this regard than any other State in the Country. One of the first studies was an in depth investigation on the leaching of soluble salts and alkalis from incinerator ash dumps" (State of California, 1952).

A number of studies have also been conducted in England through the years. One often referred to study is called, ***pollution of Water by Tipped Refuse*** (Ministry of Housing and Local Government, 1961) in which the leaching properties of a landfill were compared under "dry" and "wet" conditions.

Andersen and Dornbush (1967, 1968) of South Dakota State University have been studying, "over a period of almost ten years, the effects on ground water quality of dumping

refuse from the city of Brookings in an abandoned gravel pit located 2 miles south of the community".

Celestin M. Ble , Olivier A. E tchian (2011) reported that "the effects of the water quality on food and nutritional characteristics of stomach contents of *Oreochromis niloticus* in semi-intensive aquaculture ponds were investigated in dry and rainy seasons. Nutrient concentrations mainly ammonium and orthophosphates in water presented significant seasonal variation. The chemical composition of the total suspended solids, the main trophic source in pond is characterized by a high proportion of mineral (89%) during the two seasons".

PHYSICO CHEMICAL PARAMETERS

Physico-chemical parameters like pH, EC ,Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids(TDS) are higher than CPCB(1995) permissible limits suggesting that untreated pond water should be treated or it should be diluted before disposal, So that it does not hamper the aquatic organisms.

Goel (1997) reported that "the high level of TDS may be due to high salt content and also renders it unsuitable for irrigation hence further treatment or dilution of wastes would be required. Increase in BOD which may cause hypoxia conditions with consequent adverse effects on aquatic biota" (CPCB, 1995).

"COD of pond water is higher than the permissible limit, this indicates that the pond water is unsuitable for the existence of aquatic organisms due to reduction of DO content". (Shobana, 2008).

PHYTOPLANKTON IN POND WATER

The Swedish chemist, Per Teodor Cloleve (1840- 1905), was one of the first researchers to under take more quantitative survey of the phytoplankton community.

Ecologically and economically viable part

Use of municipal wastewater for algal cultivation could obviate the need for freshwater and the nutrients – N and P. It would also add CO_2 through bacterial activity *Chlorella minutissima* Fott *et* Nova dominated the entire phycoflora year around and through each stage of the wastewater treatment at the Oxidation pond system of wazirabad (Delhi) in India.

The ability to grow so profusely in such varied and contrasting situations made this alga unique. Beside Pollution tolerance, it grew heterotropically in dark under acidic conditions and as a mixotroph in presence of light over a range of organic C substrates. The alga also possessed potential for biofuel production. Ashish Bhatnagar & Coworkers (2010) reported that C. minutisrima war a potential biomes builder in Municipal Sewage.

M.D. Ansal (2010) reported that "Duckweed based Bio – remediation of Village ponds. Through Suitable scientific intervention there manmade water resource can be utilized for economic gains as well. Although these ponds hold immense potential for producing high quality food through aquaculture. Duck weeds hold immense potential for both nutrient recovery and utilization as fodder or feed for livestock including fish. Wastewater duck weed aquaculture is a perfect ecofriendly integrated package for converting the waste water nutrients into high quality fish protein".

Tasneem Abbasi**,** S.A.Abbasi (2010) reported that "ponds can be greatly enhanced if certain aquatic weeds are held in them. The weeds enable better treatment of wastewater in terms of greater reduction in the biochemical oxygen demand (BOD), suspended solids, nitrogen, phosphorous, metals, etc., than is possible in ponds functioning without the weeds. The additional costs of this 'upgradation' are minimal compared to the gains, because it essentially involves introduction in the ponds of easily available plants that have no economic value".

Restoration potential of Biomanipulation for Eutrophic peri- urban ponds

Anatoly De Peretyatko (2009) reported that "eight hypereutropic phytoplankton dominated ponds from the Brussels Capital Region (Belgium) were biomanipulated (Emptied with fish removal) to restore their ecological quality and reduce the risk of cyanobacterial bloom formation".

Biodiversity and Distribution patterns of Freshwater Invertebrates in Farm ponds

R.Cereghino and A. Ruggiero (2008) reported that "the importance for biodiversity of man-made farm ponds in an agricultural landscape in SW France lacking natural wetlands. The ponds were originally created to provide a variety of societal services (Irrigation, visual amenity, water for cattle, etc.) and assessed the environmental factors influencing invertebrate assemblages in these ponds. The invertebrate communities in the ponds appeared to be influenced mainly by widely acting environmental factors (e.g. area, regionalization of

assemblages) with little evidence that pond use (e.g. cattle watering, amenity) generally influenced assemblage composition".

HEAVY METAL IN POND WATER

Metal Pollution of the environment, especially at elevated concentrations, is known to adversely affect microbial activities. Siokwus and Anyanwu C.V. (2012) reported that "fungal strains isolated from the oxidation pond of the University of Nigeria, Nsukka sewage treatment plant were evaluated for their tolerance for different concentrations of metal salts, namely Cu, Zn and Mn, the fungi isolated and tested belonged to the genera *Aspergillus*, *Penicillium* and *Cladorporium*. The result revealed that metal tolerance by the isolates was highest for Zn followed by Mn and then Cu and the isolates tolerated up to 1500mg/ml for Zn followed by Mn and then Cu".

Vikram reddy (2000) reported that "the surface water qualities of Hussainragar, an entropic urban lake in the midst of twin. Cities of Hyderabad and Secunderbad receiving large quantities of external inputs – both untreated municipal sewage containing industrial effluents. Elemental analyses of water using ICP – MS revealed 26 elements including heavy metals – As, Cd, Cr, Ni, Ph, Cu, Fe, Mn, Se, Ba, Zn, Mo, V, Co, Ag, Sr, Rb, Mg, K, Ca, Al, Si, Sb, Na, Li and B in the surface water of the lake concentrations of most of there clement exceeded the maximum permissible limits of National (Indian Council Medical Research) Standard for sdrinking water".

Prabhat Kumar Raj (June 2010) reported that "Phytoremediation of Heavy metals in a Tropical Impoundment of Industrial Region. Aquatic pollution pose a serious challenge to the scientific community worldwide, since lakes or reservoirs find multifarious use and most often their water is used for drinking, bathing, irrigation and aquaculture".

ECOLOGICAL RISK ASSESSMENT OF URBAN STORMWATER PONDS

"Stormwater ponds are a common feature of the urban landscape in many countries with advanced stormwater management. Built to control the impacts of urbanization in the form of increased runoff flows, volumes and pollution loads, stormwater ponds are exposed to strong anthropogenic pressure. The benefits of this approach are discussed in a conceptual framework providing ecological quality goals for urban stormwater ponds". (Guillaume Tixier: Michel Lafont: November, 2011.)

Conclusion:

The review underscores the multifaceted impact of sewage waste on pond water quality and its broader ecological implications. Elevated levels of physico-chemical

parameters such as pH, BOD, COD, and TDS often exceed permissible limits, indicating a need for effective treatment or dilution to protect aquatic ecosystems. The role of phytoplankton in nutrient recovery and wastewater treatment is crucial, highlighting their potential in mitigating pollution. However, heavy metal contamination poses significant risks to microbial and aquatic health, necessitating careful monitoring and remediation. The management of urban stormwater ponds, while beneficial for controlling runoff, must balance ecological quality goals with practical pollution control measures. Overall, addressing these issues requires a comprehensive approach combining scientific research, practical interventions, and policy measures to ensure the sustainability and health of aquatic environments.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

REFERENCE

American Public Health Association (APHA) (1995) Standard methods for examination of water and wastewater. 19th edition. American Public Health Association, Washington, D.C.USA.

Agarker, M.S., H.K. Goswami, S. Kaushik, S.M. Mishra, A.K. Bajpai and U.S. Sharma: Biology, conservation and management of bhojwtland, Upper lak ecosystem in Bhopal. Bionature, 14, 250-273 (1994).

Ahmad, M.S.: Ecological survey of some algal flora of polluted habitats of Darbhanga. J. Environ. Pollut., 3, 147-151 (1996). Ahmad, M.S. and E.N. Siddiqui: Freshwater diatoms of Darbhanga. J. Freshwater Biol., 7, 41-48 (1995).

Ali, G.H. and N.F. Abd el-Salam: Factors controlling bioindicator for industrial pollution detection. Biomed. Environ. Sci., 12, 194-200 (1999). APHA: Standard methods for the examination of water, sewage andindustrial wastes. 14th Edn. APHA Inc., New York. p. 1193 (1975).

Ansal. M.D , Dhawan – Department of Aquaculture , Licestock Research for Rural Development Vol. 22 , July (2010)

Andoni etal 1985, Agrker etal Ludwig and Reynolds (1988) and Ismael & Dorgham (2003) – plankters studied under microscope.

Anatoly De Peretyatko, Samuel Teissier – Plant Science & Nature Management (Hydrobiologia, Nov. 2009)

Ashish Bhatnagar (Co workers) (2010), Bio – refining and carhon cycling program, Department of Biological & Agricultural Engineering – Applied Bio – Chemistry and Biotechnology part A, **Enzyme Engineering and Biotechnology (2010)**

Borics.G: Phytoplankton associations in a small hypodrophic fish pond in east Hungary during a change from bottom-up to top – down control.

Basualto, S: The Effect of physical and chemical parameters on the stouter and composition of the photos plankton community of lake Budi.

Bajpai, A.K. and M.S. Agarker: Lower plants at high Altitutes, I. Some plankton from Auli Skiing field. Ecol. Environ. Conser., 3, 97-100 (1997).

Bhuiyan, J.R. and S. Gupta: A comparative hydrobiological study of a few ponds of Baral valley. Assam and their role as sustainable water resources. J. Environ. Biol., 28, 799-802 (2007).

Bianchi, F., F. Acri, F.B. Aubry, A. Berton, A. Boldrin, E. Camatti, D. Cassinand A. Comaschi: Can plankton communities be considered as bioindicators of water quality in the laggon of Venice? Mar. Pollut. Bull. 46, 964-971 (2003).

Center, T.D., Steward, K.K. & Bruner, C.M. 1982. Control of water hyacinth (*Eichhornia crassipes*) with *Neochetina eichhorniae* (Coleoptera: Curculionidae) and a growth retardant. *Weed Sci.* 30: 453-457.

Celestin .M. Ble , Olivier A. Etchian – Centre de Recherches Oceanologiques, Department of Agriculture (Dec. , 2011)

Dufour, Alfred P., Edley R. Strickland, and Victor J. Cabelli. 1981. Membrane filter method for enumerating *Escherichia coli*. Applied and Environmental Microbiology 41(5):1152-1158.

EPA. 1985.(Environmental Protection Agency) Test methods for *Escherichia coli* and *Enterococci* in water by the membrane filter procedure. EPA/600/4-85/076. Office of Research and Development, USEPA, Washington, DC.

Faechem, R.G. (1980) Bacterial standards for drinking water quality in developing countries.

Hallegraeff : et al (1995) – The Manual of Harmful Marine Micro algae Second edition, 2004

Lancet. 2:255-56. Geldreich, E.E. (1998) The bacteriology of water. In: Colier, L., Balows, A.and Sussman, M. (Eds.), Microbiology and microbial Infections. 9th ed. Arnold publication, London

Mallin .M.A.Errsign. S.H. Wheeler, T.L & Mayes. D.B (2002) Pollutant removal efficacy of three wet detention pond journal of Environmental quality , 31,654-660.

Who (1999). Toxic Cyanobacterion in water. A guide to their public health consequences, monitoring and mgt.

Moutinetal, 2002, Thingstad, TT., WAMBEDE, FV., 2002 Doers competition for an molecular phosphate supply explain the predominance of the cyanobaeterium synechococeus. Zimnology and oceanography.

Pathak H. (2011), *Doctoral thesis (submitted)*, Dr. H. S. Gour central university, Sagar, M.P., India; Pathak H., Limaye S. N. (2011), *Study of seasonal variation in ground Water quality Chemical parameters of Sagar city (M.P.) by principal component analysis and evaluation*, E- Journal of chemistry, 8(4), 2000-2009

Per Teodor Cloleve (1840 – 1905) – Swedish Chemist – Quantitative survey of Phytoplankton.

Prabhat Kumar Raj (June 2010) Environmental Sciences – Environmental Monitoring and Assessment (Vol. 165 , 2010).

S. Siokwu, Anyanwu.C.V - Department of microbiology university of Nigeria, African journal of Microbiology Research (2012).

Shyamla R., Shanthi M., Lalitha P. (2008), *Physicochemical Analysis of Bore well Water Samples of Telungupalayam Area in Coimbatore District, Tamilnadu*, India, E-Journal of Chemistry, 5(4), 924-929;

Vikram Reddy . M, Sagar Babu. K, Balaram. V, Satyanarayanan .M- Department of Ecology and Environmental Science Pondicheroy Central University, Environmental Monitoring and Assessment Page (1991 – 2000).

WHO. Basic Environmental Health, Geneva, 1997.Elmund. G.K., M.J. Allen, and E.W. Rice. 1999. Fecal Coliform Populations as Indicators of Wastewater Treatment Efficiency. *Water Environment*