A study of Water Quality of *Banganga Tank*: A Freshwater body in Mumbai, Maharashtra

Nigrel Kelly[1],Tulpule Aryaman[2], Thadhani Nikhil[3]and Joshi Mayuresh[4]*

[1,2,3,4]Department of Life Sciences, K.C. College, 124, Vidyasagar Kundnani Square, Churchgate,Mumbai – 400020, India.*
**E-mail: mayuresh.joshi@kccollege.edu.in*

Abstract:

For a closed waterbody in an urban location, regular checking of the water is very important. Any deviation from normal values for the quality defining establishing parameters suggest potential contamination and pollution of the water body due to anthropogenic intervention. One such water body affected by urbanization is the Banganga Tank in Mumbai. In the current research work, water quality at Banganga Tank has been evaluated in terms of water quality parameters such as pH, Alkalinity, Salinity, Chlorinity, Total Hardness, Dissolved Oxygen, Chemical Oxygen Demand and Biological Oxygen Demand. The values obtained have been compared with the acceptability criteria set by Bureau of Indian Standards (BIS). Water collected from the pond was physically observed to be eutrophic and contaminated due to anthropogenic pollution. These optical observations were supported by the results obtained. Levels of all the above-mentioned parameters were found to be above the acceptable limits. Results suggest that the chemical imbalance in the water is primarily responsible for algal blooms observed and raises a warning for overall degradation of the waterbody. Awareness regarding the degrading conditions of Banganga Tank needs to be generated on war-footing. With help from local governmental authorities, scientific steps for cleaning and rejuvenation of the waterbody need to be implemented. Further in-depth evaluation encompassing other water quality defining parameters will be able to shed more light on the current situation and provide the necessary information for the restoration effort.

Key Words:Water testing, Banganga, Chemical investigation

Introduction:

A pond ecosystem is a closed community of organisms within a water body that serves as an important habitat for several species of aquatic animals, algae, plants, micro-organisms, arthropods, waterfowls, etc. One such ecosystem is the *Banganga Tank*, an urban, spring-fed pond in Malabar Hill, Mumbai, India (18.9455° N, 72.7936° E). The tank is surrounded by numerous temples and *Dharamshalas*, indicating its historic and religious significance. According to Indian mythology, when Lord Rama felt thirsty on his way to Lanka to rescue Sita, he halted here, and shot an arrow piercing the ground causing water to sprout. Even today, there is a pole in the pond signifying where the arrow struck (Sengar 2019). Sadly, the amount of pollution in and around this water tank ruins its serenity and holiness.

Oblivious to the condition of *Banganga*, we visited the pond for the first time in August 2019 to collect water samples to observe its microflora; however, upon witnessing the declining state of the pond, we felt it necessary to assess the probable causes for the same while emphasizing on the need to carry out scientific research to determine the quality of water, thereby providing valid explanations for the pond's condition.

Depleting Conditions of Banganga:

In 2011, the Times of India released an article highlighting the loss of aquatic life of the *Banganga Tank* – people who had encroached the surrounding land, were seen bathing, disposing household waste, washing clothes, utensils, etc. in the pond (Times of India, 2011); such activities were also observed during our visit in 2019. In addition to this, the major issue of concern was that of the illegal channels that deposited sewage into the tank, severely damaging its ecosystem.

Further, a 2014 article in the Indian Express stated that due to the religious importance of this tank, various rituals have been conducted along its banks that did not only pollute its waters but also led to overfeeding and eventually the death of several fishes (The Indian Express, 2014). The same was supported by another article in the Hindustan Times, 2017, that revealed the harmful effects of religious activities on aquatic life. Though this article mentions that awareness measures have been carried out to maintain the cleanliness of the pond, even today, the condition of the pond seems to be deteriorating (The Hindustan Times, 2017).

In September 2020, the Mumbai Mirror reported that on-going construction work in the vicinity of the tank had made its waters muddy (The Mumbai Mirror, 2020). The authorities had suggested to tentatively stop the work and undertake a geotechnical investigation to thoroughly identify the cause; however, even after a month, the situation remained unchanged as stated by the Times of India in October 2020 (The Times of India, 2020). Additionally, the Directorate of Archaeology and Museums decided to identify the source of the pond so as to prevent its contamination with construction debris. Even so, in 2021, the newspaper Deccan Herald mentioned that the construction work continued to deplete the condition of the *Banganga Tank*, forcing the government to take action (The Deccan Herald, 2021). In all, these various newspaper articles also seem to articulate the need for scientific intervention to preserve this heritage site.

Plausible Effects of these Activities:

Pond ecosystems are delicate ecosystems which can be affected in various ways due to anthropogenic interventions. The effects of many of the anthropogenic activities, carried out in and around such an ecosystem, are not always well prognosed. The plausible effect of such activities has been listed below:

Sewage: Disposal of sewage waste into water bodies introduces organic matter, chemicals, micro-organisms, etc. in its aquatic ecosystem hampering its health and ecology. Decomposers, like bacteria, consume the dissolved oxygen in water to metabolize the organic matter accompanying the sewage, resulting in the formation of oxygen-depleted zones within the water-body. This leads to suffocation of the organisms that are present as a part of its natural ecosystem. When people suffer from infectious diseases, their sewage, if left untreated, also contains harmful pathogens. Water contaminated with such sewage, serves as an agent of several faecal-orally transmitted diseases like cholera, typhoid, etc. (Blaettler 2021).

Construction Waste: It has been well documented that the concrete and mud produced as construction waste if released in water bodies can increase the pH of water (Zeng 2018). A change in pH has always spelled disaster for a pond-based ecosystem. Moreover, the increased turbidity caused by the deposition of mud decreases the availability of light for photosynthesis in aquatic autotrophs. These waste influxes can harm aquatic life by reducing their growth rate and resistance to diseases, thereby hampering proper development of eggs and larvae, altering natural movements of organisms in and around the water body and more (Zeng 2018; Minnesota Pollution Control Agency 2008).

Detergents: Domestic activities in and around the pond lead to the entry of cleaning agents into the pond. These additions have been well documented to be poisonous to aquatic life. Surfactants in these chemicals severely damage the external, protective mucous layers of fishes as well as their gills. They also decrease the breeding capacity of aquatic organisms and lower the surface tension of water causing the organisms to absorb more amounts of dissolved chemical substances than usual. Phosphorus and nitrogen compounds in detergents, may also stimulate increased growth of algae, leading to eutrophication of the water body. Additionally, the use of powdered detergents significantly increases levels of pH, total dissolved solids, chlorides, sulphates, carbonates and bicarbonates (Goel & Kaur 2012; Federal Public Service, Health, Food chain Safety and Environment 2016).

Religious activities: Ponds that are used for religious activities and idol immersion show poor quality of water with higher-than-normal levels of most physiochemical parameters. Pouring human ash into water bodies after cremation increases their biological and chemical oxygen demand which adversely affects the ecosystem. Idol immersion not only obstructs the natural flow of water but also exposes the waterbody to numerous heavy metals that cause a significant change in the physiochemical properties, ultimately damaging aquatic life (Gupta et al. 2011; Bhattacharya et al. 2014; Verma & Shrivastav 2018).

Therefore, the aforementioned ongoing anthropogenic activities around the *Banganga Tank* could pose severe consequences to the condition of the tank in subsequent years. Hence, the true sources of pollution of the pond need to be ascertained in order to put forth mitigating measures to restore the health of the waterbody.

Methodology:

Physicochemical evaluation of water sample:

The evaluation of the water quality parameters aids in appraising the degree of suitability of a water sample; thereby, providing an understanding of the level of pollution in the aquatic ecosystem. This also provides a window to understand the impact of polluting activities and anthropogenic intrusions on its inhabitants as well as the surrounding environment. Thus, the data generated from a physicochemical water analysis of the pond could be used to devise methods to further extrapolate a prognosis of the water health and to revive the ailing waterbody (Reza & Yousuf 2016; Sajitha & Smitha 2016; Rana & Jain 2017).

In the current research work, the water quality parameters like pH, Alkalinity, Salinity, Chlorinity, Total Hardness, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) levels of water at *Banganga Tank* were estimated.

Multiple site visits and sample collection drives were undertaken. Random sampling was implemented and samples collected from the tank were stored in a thoroughly cleaned and dry polyethylene container. Analysis of physicochemical parameters such as pH, alkalinity, total hardness, chlorinity, salinity, dissolved oxygen, etc. was carried out as soon as the samples arrived at the laboratory. A universal indicator, pH strip, and a pH meter were used to record the pH of the water samples, while values of the other parameters were found using the standard methods of examination of water outlined by the American Public Health Association (APHA; 23rd edition, 2017).

The data collected by conducting tests was repeated in triplicates and the averaged-out readings obtained were compared to the acceptable limits as given by the Central Pollution Control Board (CPCB 2008) and the Bureau of Indian Standards (BIS). The values of parameters whose values fall out of the acceptable limits has been used to hypothesize the probable condition of the *Banganga Tank*. In addition to this, a detailed observation of the microflora of the waterbody was also studied by observing the water sample under a compound microscope. The organisms observed were compared with available literature for identification purposes.

Results:

Careful monitoring of the water quality parameters is a vital step to understand the biotic and abiotic interactions that are at work in the water body. It helps us understand the health of the water body as well as the positive and negative effects of various extrinsic factors on its flora and fauna, their growth patterns and health. Though each of the estimated parameters individually may not provide sufficient information about the condition of water at *Banganga Tank*, several of these parameters together reveal the dynamic processes and interactions occurring in the pond.

Moreover, each parameter can be assessed to observe its effect on the health of an aquatic organism, in a delicate and complex pond-based ecosystem, deviation in the levels of these quality parameters affects each other (Makori et al. 2017). Thus, maintaining balanced levels of water quality parameters is fundamental for both the health of the flora-fauna and the water body itself.

In this study, the water quality parameters pH, Alkalinity, Salinity, Chlorinity, Total Hardness, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) were evaluated. The chemical components of the water body influencing the values of the above-mentioned parameters are dependent on each other. The ionic concentration observed to influence the pH and chlorinity for example also determines the COD and BOD of the water-body. The current results also support these interactions of the parameters.

pH: The pH of water determines the level of its acidity or alkalinity. Deviation from the optimum level of pH results in change in the toxicity of the waterbody. The sample procured from *Banganga Tank* was observed to be slightly alkaline in comparison to normal standards justifying the observed presence of large amounts of algae in the tank. A pH sample value

between 6.5 – 8.5 is marked as acceptable under IS 10500: 2012 by Bureau of Indian Standards (BIS, 2012). Algae have been reported to increase the pH of the water body. The eutrophic algal bloom observed may also be an indication of excess nutrient pollution which may be the actual reason for the increase in pH (Fondriest Environmental, Inc. 2013; Lenntech 2020).

Salinity: It is the quantity of salts present in the water sample. For freshwater organisms, maintaining an osmotic balance between their cells and surrounding fluids is vital and is affected greatly by the salinity of the surrounding water (Willard et al. 2019). The salinity of water of *Banganga Tank* was observed to be within permissible limits.

Alkalinity*:* Alkalinity is determined by the number of alkaline substances (hydroxyls and carbonates) present per volume of the water sample. Analysis of the samples collected from the *Banganga Tank* revealed a high total alkalinity which can result in the loss of aquatic life. The total alkalinity was observed to be 400 mg/L while IS 10500:2012 by BIS suggests a value of NMT 200 mg/L as the acceptable limit (BIS, 2012). High alkalinity has been well documented to damage fish gills, eyes, and skin. A two-fold increase in the levels of total alkalinity is an essential factor which needs to be assessed in case of the *Banganga Tank* as extreme levels of alkalinity may increase the toxicity of certain substances that are otherwise not toxic in a neutral medium (Judkins and McTeer, 2020).

Chlorinity*:* Chlorinity refers to the total chloride ions per volume. High levels of chlorine can have a negative impact on the aquatic ecosystems. The water samples collected were found to have a higher chlorinity; the amount of chloride ions was observed to be 461.5 mg/L whereas IS 10500:2012 suggests an acceptable limit of 250 mg/L (BIS, 2012). Studies propose a sensitivity of free-floating planktonic crustaceans to chlorides concentrations. These crustaceans feed on algae that promote eutrophication, hence an increase in chlorinity indirectly leads to abundance of algae (Salmon and Trout Conservation, 2017). The presence of algal bloom in *Banganga* supports the observation regarding chlorinity levels which may also be attributed to the loss of zooplanktonic diversity as a result of higher levels of chloride ions.

Total Hardness*:* This parameter indicates the quantity of mineral ions (Ca^{2+}, Mg^{2+}) present in the water sample. The hardness of water influences osmoregulation in organisms, suitable levels of hardness allow freshwater fishes to perform osmoregulation and maintain constant levels of water influx with minimal efforts. However, high concentration of Ca^{2+} may lead to

breeding issues and organ blockages in soft water organisms (Gulyani 2018; Iles 2021). *Banganga Tank* water shows a higher but acceptable total hardness value. Sample shows a Ca^{2+} ions concentration at 56.136 mg/L which falls within the acceptable limits of 75.0 mg/L as per IS 10500:2012 (BIS 2012).

Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD): DO refers to the atmospheric oxygen dissolved in water. According to Indian Water Standards IS 2296:1992 (BIS 1992), a minimum dissolved oxygen concentration of 5 mg/L is necessary to ensure a reasonable freedom from oxygen consuming organic pollution. Indian Water Standards IS 2296:1992 (BIS 1992) further remarks that the BOD (5 day) value of 3.0 mg/L or less is a necessity for ensuring reasonable freedom from oxygen demanding pollutants and prevent production of obnoxious gases.

In qualitative estimation of DO, BOD, and COD, it was observed that DO values were found to be lesser whereas both BOD and COD values were observed to be more than the permissible and acceptable limits as set by Bureau of Indian Standards (BIS 2012) (BIS 1992). Eutrophication has been reported to cause fluctuation in DO levels and can also be held responsible for increased BOD and COD values (Rounds et al. 2013). A higher COD stipulates that there is an increase in the number of oxidizable substances in the waterbody, leading to the mortality of aerobic organisms due to the reduced levels of dissolved oxygen (Reza & Yousuf 2016). The reduction of DO levels hence indicates the environmental health of the aquatic ecosystem by determining the extent of pollution in the water body. The increase in BOD and COD has also been reported to be proportional to increase in domestic wastes (USGS 2021). Domestic waste has been a reported problem with *Banganga Tank* due to its sociological and religious importance.

Additionally, the microflora study carried out in August 2019 revealed a variety of microorganisms that inhabited the *Banganga Tank*. Phytoplankton, such as *Scenedesmus*, *Pediastrum, Eudorina, Oscillatoria,* and *Gomphosphaeria*, were clearly distinguished in the sample. Certain zooplanktons like *Paramoecium, Daphnia, Brachionus,* and *Copepoda*, were also seen.

Discussion:

The results obtained in the chemical analysis and on-site observations of the conditions at *Banganga Tank* recorded during the visit suggest that the water of *Banganga Tank* has become eutrophic. This can also be observed by the presence of algal blooms in some patches

of the tank. Based on the changes reported around the pond in recent years, this eutrophication can easily be attributed to anthropogenic interventions and hence is a cause for concern. These observations also suggest the development of a hypoxic zone in the hypolimnetic zone of the tank; this possibility needs to be further evaluated.

Though as mentioned earlier, only these parameters may not be able to completely define the status of water at *Banganga Tank*, they can be a significant proof to raise a flag of concern for the waterbody. Further, detailed studies shall be able to better shed light on the biochemical condition of *Banganga Tank.*

Phytoplanktons and zooplanktons form the basis of the food chain and can be used as indicators of pollution effects to determine impacts of aquatic contaminants; therefore, as an ongoing component of the research work, seasonal and temporal evaluation of effects observed on the micro-floral composition is underway. The proliferation of these organisms is influenced by anthropogenic factors; observing the variation in their growth and diversity can help understand the ecological conditions of such ecosystems.

Conclusion:

Water possesses a natural capacity to neutralize contamination, however, when water bodies are used as sinks for uncontrolled disposal of numerous contaminants produced by urbanization, industrialization, agriculture, etc., it loses its self-generating ability. Unfortunately, the *Banganga Tank*, which is not just an aquatic ecosystem but also a place of historic and religious significance in the city of Mumbai, has fallen prey to such anthropological activities.

The results obtained in the current research work illuminates the necessity of undertaking a thorough scientific examination

Therefore, this article attempts to illuminate the necessity of undertaking a thorough scientific study to determine the exact sources of pollution of the *Banganga* by means of a detailed and thorough physicochemical water analysis supported by review of available literature to help formulate an articulate plan to tackle the problem at the source.

Alongside the analysis, encouraging people and creating awareness about the status of the waterbody is the need of the hour. This would not only improve the quality of water but also reduce the expenditure of treating polluted water. Awareness programs could be arranged

along with regular clean-up drives while working in tandem with local authorities to aid in the upkeep and sanitation of the *Banganga Tank.*

Construction activities should be made to incorporate appropriate best management practices (BMPs) to minimize the detrimental impacts on the overall water quality of surrounding water bodies. Recent BMC reports and cited high court orders are testaments of this need. Lastly, in order to ensure that all initiatives are having a positive impact on the pond ecosystem, regular testing of physiochemical parameters should be performed, while maintaining systematic records of all the tests for reference.

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