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FROTHS, FIRES AND FIGHTS OVER SUSTAINABILITY OF BELLANDUR LAKE - A CASE FOR INTENSIVE ENVIRONMENTAL DETECTIVISM

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ABSTRACT: Bellandur Lake, a 800acre, 1000year man-made waterbody in Bangalore suffers sewage ingress, globally infamous for burning four times recently and foaming to envelope passing vehicles to make bridge crossing hazardous. A reincarnated Alessandro Volta seeing it now would rechristen this "Ignis Astutus (not Fatuus)" after some insightful 'Environmental Detectivism'. Various stakeholders have used 'lake-centric environmental activism' with 'doomsday predictions deploying meagre data and questionable analysis to play on peoples' fears while reducing the lake to a real-estate 'El-Dorado' worth €10Billion. Creating sufficient nuisance level could convince the administration to convert it to real-estate while the environmentalists helplessly cry foul. Further, not knowing where the next scandal will emerge, administration and environment regulatory bodies were on the defensive, while all available data strongly supports its continued existence. Strong public opinion and judicial activism forced the administration to close all commercial and 'industrial' activities in the catchment for over 3 months. Yet, foam did not stop - negating the phosphatic detergent, rogue industry, 'underground laundry' theories put out as cause of foam. The 'Ghost' of heavy metals then surfaced when the scare from phosphatic detergent or toxic foam, etc. failed to impact citizens, environmentalists, judiciary, etc. Our analysis indicated need for a balanced, neutral decision-making system that supersedes environmental trade-offs, developmental advantages, short-long term commercial gains, individuals Vs Commons, market viability Vs long-term sustainability conflicts. This paper recounts the 'Environmental Opportunism" Vs academic and administrative reality conflicts and emerging issues for over 3 decades and portraying it as exemplar for emergent socio-political and environmental conflicts.

1. INTRODUCTION

A lake that spews out foam at passers-by, a foam that sometimes catches fire, a lake with floating macrophytes that burns for over 8 hours choking the neighborhood with smoke and ash is definitely an enigma that requires a scientific, environmental and hard core detectivism to pin such an environmental 'crime', identify the causes and prevent such occurrences in the future; an event that can repeat at other 35,000 lakes in the state of Karnataka, South India. Situated in the Eastern region of Bangalore, Bellandur Lake is a 360ha man-made water body (largest in Bangalore) designed to collect run-off from about 160km^2 upstream catchments. Such manmade lakes were built between a 100 and 1500 years earlier and these allowed human civilization to live comfortably (water security) in an otherwise drought-prone semi-arid tract of this part of the Deccan Plateau (South India). These man-made lakes were

predominantly used to supply water for protective irrigation downstream of the Lake as well as allow for its use for various domestic needs. Villages and settlements began nearby such man-made lakes as these not only made open water available, but it also recharged ground water and allowed the use of open wells (safe sub-surface water) during long periods of drought. The City of Bangalore had over 250 small and large lakes during 1960's with a water spread area ranging from 2-220ha for each of these lakes. As the city grew and population multiplied over ten-fold, wastewater discharged from houses could neither be contained nor treated adequately in STPs before reaching such waterbodies downstream and cause severe organic matter pollution (and eutrophication). This is because most of the domestic sewage escaping the STP systems and their capacities flowed along these very same run-off water courses to mix up with rainwater collected in these man-made waterbodies.

2. THE PROBLEM

Bangalore city grew from about a million in 1970 to about 12million today, not to mention a whole lot of suburbs also becoming a part of this developmental process triggered by the IT and small industry boom. More recently, housing has caught upon this growth and vast areas of the city that was once verdant and green (>45% green cover) has now been converted to real estate and housing. The city also brings in about a billion liters of fresh water from a nearby river while also picking up an estimated another 70% from deep aquifers. This indicates that nearly 1500 million liters per day (MLD) would be discharged as wastewater. The City had only a third of this capacity for treating sewage. Consequently, over two thirds of the wastewater generated escape the STP systems and reach various waterbodies. Over the last three decades the several attempts have been made to change this and sewage has been diverted for many of the water bodies, however, the urban expansion has almost always surpassed this capacity and consequently some extent of sewage always enters many of these water bodies. There are very few polluting industries discharging large quantities of wastewater into these water bodies in this catchment. Further, bulk generators of wastewater have been legislated under a different law that necessitates that large tenements (>20 dwelling units) treat the wastewater they generate and recycle in-house as much water they can reuse. Over the last two years, attempt has been made to treat and send treated wastewater to recharge ground water in the dry neighborhood district of Kolar (about 210MLD). However, these big water bodies, the Bellandur and Varthur Lakes in the Eastern Part is also home to the people who work in the famed 'Silicon Industry' of Bangalore making the land here some of most expensive real estate. As seen in the photo below (Figure 1), the Lake is surrounded by over 500 large apartment buildings that are often suspected to release partially treated or untreated water directly into this water body. Being so close to the water body it is also difficult to know which of these establishments are 'clandestinely' carrying out such discharges.

Figure 1: Bellandur Lake skyline showing some of the most intensely populated and built up area. The view shows about a quarter of the shoreline only. At this time the water of the lake in the foreground is drained to clean it up.

3. LAKE AS A FACULTATIVE LAGOON

Several studies have been carried out on the water quality and status of Bellandur Lake and the Varthur Lake that is immediately downstream and receives the water discharged from this lake. Both these lakes suffer the same pattern of sewage ingress, macrophyte infestation, algal blooms, anaerobic-anoxic zones and partial treatment of the input sewage. While Bellandur Lake has several points of sewage /run-off inlets, the Varthur Lake system has fewer inputs. It is estimated that about at least about 500MLD of sewage passes through these two lake systems apart from the run-off after severe rainfall events. It is estimated that based on a Nr concentration in the range of 50-60mg/L, the total daily Nr flux ranges between 25-30tpd (Chanakya et al, 2010). Similarly, the total P has been gradually increasing from about 2-6ppm in 2000 to about 8-12ppm today (Das et al, 2019). It is not clear how such large increases in P levels have occurred over the period.

For a long time now it is believed that 'cheaper phosphatic detergents' were the major cause and also directly responsible for the foam and froth production at the outlets. It is now clear that most of the commercial detergents do not contain P both because P is itself expensive and most detergent manufacturers across the world have voluntarily avoided their use. On the other hand, the extent of detergents in the wastewater has increased significantly. Although the total anionic surfactants were not measured earlier, current studies indicate that it has reached levels between 15-20ppm in the sewage entering the lake and when water leaves the lakes the levels of detergents have only diminished marginally [Das et al, 2019].

Earlier research indicated that due to significant sewage ingress, these lakes zonate into three typical zones of function namely an initial anaerobic-anoxic zone that occupies the upper 50% of the water spread area or representing between 1-2d of HRT. A significant anaerobic decomposition removes the C content of the sewage entering the lake through anaerobic processes. The next zone is micro-aerophilic zone which is characterized by the rich activity of Euglenoids and are responsible for a significant level of water becoming clear. The third zone is dominated by algae both chlorophyceans (green algae) and cyanophyceans (blue-green algae), depending upon the nutrient levels. This zone is responsible for increasing the oxygen levels which can reach supersaturation levels crossing 12mg/L at mid-day and ~2mg/L at night.

Overall the organic loads are reduced to about 10-20% of the original levels in incoming sewage. The lakes function in this manner only when there is low macrophyte cover (<30%). However, during the post monsoon period, post winter and approaching summer, the lake is gradually covered to a greater extent by macrophytes. Thus, during peak summer during months of May-June, over 90% of the Lake is covered by the macrophytes. The anaerobic, Euglenoid and green-algal functions are almost completely arrested. The Lake functions merely as an anoxic pool. Much of the organics, nutrients and detergents pass through without too much transformations. However, with the onset of pre-monsoon and monsoon periods, there is incidences of heavy downpours and run-offs and this perturbs the typical summer functioning of the Lake.

4. THE EMERGENCE OF FROTH AND FIRES

With such a large catchment (>150km^2) the runoff levels are often quite high. As a result, within a few hours, the run-off from the catchments reach the two Lakes. The water level in Bellandur Lake has been estimated to increase by about 60-75cm on some of such occasions. Such high runoff incidents create a high rate of overflow over the spillway. This in turn, supported by the high levels of undecomposed surfactants in the sewage (Lake water), creates an ideal situation for froth formation. This froth, created by the spilling over the waste-weir from a height of about 4m, is quite stable. As this

process lasts several hours to days till the lake empties itself, froth produced accumulates immediately downstream and is carried off by high velocity winds that are characteristics of this monsoon period. Large chunks of foam thus travel farther down, pushed by winds onto the roads and dwellings nearby.

Photos in Figure 2 indicates the severity as it often creates obstacle to traffic. It is important to understand that these incidents occur only during periods of high run-off and when the Lake empties itself rapidly over the waste weir or spillway. Another important observation during this period is also that as the water levels rises significantly and the wind blows in the direction of the spillway, firstly a large part of the floating macrophytes also disgorged over the spill way and the lake water surface gradually becomes devoid of the floating macrophyte cover. Second, due to the high velocity winds and high inflows a large part of the settled sludge is also rendered afloat and is rapidly pushed over the spillway. This way the lake become free of a large area of macrophyte cover and also much of the sludge that is accumulated through the year. The role of the sludge being washed off in the phenomenon of foam production is not clear, although there is enough evidence to suggest that a lot of detergents tend to bind to sludge and settle down in still waters. Further, the presence of significant levels of algal population in water and their contribution to foam formation is still not clear [Mahapatra et al, 2012].

This foam formation during high run-off periods is seen as a nuisance and it generally becomes newsworthy only when the foam occupies a significant part of the road downstream of the Lake and blinds traffic. Needless to state, the foam levels are compounded by the fact that very little of aerobic conditions exists in the lake where there is potential for some of the detergents present in the water to be degraded. During the early years (2006-2016), the foam occurrence was attributed to the high levels of use of phosphatic detergents used by rogue industries and 'cheap' detergents sold by unscrupulous manufacturers. However, after extensive analysis of the P content and the types of detergents found, this theory has generally now received a backseat [Das et al, 2012]. Yet, this foam is labelled toxic and is often reported to cause serious skin allergies and infections. On the other hand, several steps have also been taken up by the City Corporation. Firstly, they have slowed down the fall by creating a ramp. Second, water from the stream is pumped strongly over the foam to break it. Third, the outfall is now changed to a sluice gate that will discharge the outflow water directly to levels of the stream without creating a waterfall and therefore a reason for foam to build up and accumulate. Fourth, a tall netting is provided on the Lake side of the road to arrest the foam.

Figure 2: A photo collage showing frothing in the Lake overflowing onto residential areas, foam affecting the traffic, Lake macrophytes on fire (middle) and top right showing firemen extinguishing fire of dry grass on the banks and bottom right showing even the foal having caught fire. Photocollage is made from various internet sources indicated in references and is acknowledged.

Another interesting and intriguing part of the Lake's being is the frequent fire that occurs on the Lake itself. Ironically, the floating macrophytes and dry grass on the banks tend to catch fire during the dry months that could range from early spring (January) to late summer (August). Almost every year, as an annual event, the banks with dry grass or the dried and floating macrophytes tend to catch fire. Although the causes of such fires are difficult to pin-point or forecast, the inaccessibility of the burning parts in the Lake or the dry grass banks makes fire control quite challenging. As a result, the fires can continue burning for periods between 8-30hours. With the long shoreline densely built up as seen in Figure 1, it definitely troubles the residents nearby.

5. SOCIETAL RESPONSES AND INTERPRETATION OF ECSI

This generally sets the citizens and media to react severely and many causes are put forth from a perspective of environmental failures or environmental crime. Sometimes, even the froth is shown to catch fire. This aggravates the strong debates. The foam is then attributed to unknown toxic chemicals released and is described to be toxic to humans. A few Lake Marshalls attribute this to waste processors setting fire to non-processable rejects of waste processing, namely poor quality plastics and paper [Intenet-1-3]. It is also true that the extent of foam production has gradually increased from 2012 to current levels when the foam earlier was only along the spillways but now extends nearly up to a kilometer downstream before disintegrating on its own. Another interesting observation has also been the increased use of highly chlorinated anti-microbials in daily life such as Triclosan, etc. reaching up to a concentration of 2ppm. At these concentrations, a large number of micro-organisms involved in anaerobic degradation of organic compounds are arrested significantly [unpublished work at CST].

The foam and fires are likely to increase in coming years. With the cost of land being as high as €2500/m^2, there is always significant realty pressure to convert this waterbody, albeit even temporarily to some form of real estate. A non-technical cause is also that the high value of land at this spot creates extensive illegal and unauthorized activities that leave behind lots of unclaimed and combustible wastes such as non-recyclable plastics, paper and packaging. Their piling up behind dwelling areas or to ensure no traces being left by illegal operators, these are set on fire early in the evening so that no one can notice the start of the fire until it extinguishes itself by completely burning up before the next dawn. Such events are planned deliberately to leave no incriminating clues at the site. This approach thus leaves behind very little traces for Environmental Crime Scene Investigation (ECSI) except create some form of deductions from the unburnt components. It is often clear what components were set afire – by accident or natural causes. Another complicating ECSI is the STP sludge tankers illegally letting off their loads into the lake is another environmental crime that often goes undetected because it is done at night.

6. THE ECSI CHALLENGE

With regards to the foam spreading across the roads, the third component of the ECSI, it is not clear who is directly and indirectly responsible. A market system that produces and sells domestic detergents with highly stable foam is on the one side. On the other side various governmental systems that have permitted the sale of such detergents which is known only to be degraded aerobically. However, there are few aerobic treatment cascades in the overall treatment system. Who then is responsible? A third and compounding problem is the extensive advertising, attitude changing campaigns, sale and use of anti-microbial handwashes that are antagonistic to anaerobic systems and these slow down the natural anaerobic digestion process. This slows down the natural breakdown of

these compounds in the Lake. Who should then be responsible - the users, the mind-changers or the sellers? Naturally, anyone implicated in this is also responsible party to the ECS.

Fourth, it has been shown that although sewage enters the water body, when kept free of floating macrophytes, the water body becomes capable of bringing about a reasonable level of wastewater treatment [Mahapatra et al, 2011]. However, who should keep the water body free from floating macrophytes? As the Lake has many governmental departments that take divided but interdependent responsibilities, there is very little overall responsibility to any single organization and therefore there is a need to fix the responsibility to keep the water body free of floating macrophytes. It is then possible to ensure that the Lake is able to degrade a large range of problematic chemicals even in the presence of sewage ingress to provide the aesthetic satisfaction and water security.

Another important issue with regards to "Expert Opinion" is the presence of a bevy of 'instant experts' who generate a whole lot of theories that float around in public information space and is highly publicized without ensuring credibility or competence. For example, the foam is branded toxic or emerging from toxic chemicals without assigning reasons or evidence. This is especially significant where media is fed with "doomsday" predictions of toxicity, disease spread, heavy metals, etc. These are spread irresponsibly while a deeper analysis can link this to some form of ulterior motives and needs to be curbed. In the end, the situation is quite complex that today the waterbody is being desilted and cleaned up at a cost of €100 Million. Yet, there is no mechanism to ensure that these prevailing issues are not brought back and responsibility to overcome them is not allocated with sufficient clarity.

7. CONCLUSION

In conclusion it may be stated that this situation is brought about firstly by group of environmental authorities poorly managing the Lake situation. They were on the one side capable of setting an example for establishing the appropriate and sustainable solutions to these local problems. On the other hand, there is a market mechanism that sells and makes available various household chemicals including detergents and handwashes but is insensitive to the aftermath of overusing or misusing these household chemicals. Third there is an inadequately defined governance mechanism that is not clear about how to deal with these situations. The reigning laws and guidelines dealing with this situation is adequately nebulous to create a situation of dignified non-action. There is inadequately defined /responsible reporting and media systems that capitalize on the "doomsday" predictions rather than finding a concerted set of solutions and increase the public fear who cannot question as why 'foam on a pretty model is attractive while the same on the road is life threatening'? There are multiple actors in this ECSI all with different stakes, motives and approach and interference and need to be sorted out to bring about clarity in how to deal with the situation. The 'low hanging fruits' approach will only defer the solution to ECSI and thus needs a deeper analysis of the situation and possible solutions.

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