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Indirect Potable Reuse of Sewage at Chennai-An Appraisal of Feasibility

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ABSTRACT

Necessity is the mother of “invention”. Such was the case in Windhoek, Namibia in 1968 when it faced a grueling water drought. The “invention” was the biologically treated city sewage was reused by blending it with the scarce fresh water and then put through the public water treatment plant for public distribution. This has since been upgraded and water borne epidemics have never been reported. The recent and most talked about is Singapore’s NeWater which mimics the early Windhoek system except that the biologically treated city sewage is further treated by membranes and disinfected with Ultra Violet before a similar blend, water treatment and distribution. Most of the reuse instances in the world are in between these two technology extremes. The necessity of pursuing such an option is looming large at Chennai and this paper explores the feasibility.

INTRODUCTION

The management of wastewater and stormwater in coastal urban areas is inextricably linked to overall coastal management objectives. While wastewater and stormwater management constitute an immense enterprise, they take place in the context of a multitude of other human activities and natural processes within the coastal zone. In addition, there are many difficult tradeoffs associated with the array of options available for wastewater and stormwater management.

The problems associated with sewage disposal have become a major problem of the urban world due to increase in human population and urbanization. The commonality of sewage related problems throughout coastal areas of the world is significant since these areas are inhabited by over 60% of the human population. Consequently, domestic wastewater discharges are considered one of the most significant threats of the coastal environments worldwide (GPA 2001). Environmental effects associated with domestic waste-water discharges are generally local with transboundary implications in some areas. Coastal waters are facing a variety of pressure affecting both the ecosystem and human health through sewage waste-water discharge and disposal practices that may lead to introduction of high nutrient loads, hazardous chemicals and pathogens causing diseases. The adverse public health, environmental, socio-economic, food quality and security, and aesthetic impacts from sewage contamination in coastal areas are well documented. (LuGer and Brown 1999, Tyrrel, 1999, Danulat et al 2002, WHO, 2003). Pollution of the coastal water usually interferes with various water uses. Cultured bivalves are generally reared in areas that are often densely populated and are sensitive to heavy pollution from human activities. Pathogens transmitted by human feaces are most commonly involved and the discharge of sewage polluted by human and animal pathogens into the sea represents the main source of bacterial pollution. Every pathogen present in seawater may be trapped and concentrated in the tissues of the bivalves and so represents a potential health hazard.

Chennai is a coastal metropolis on Bay of Bengal with a 2021 population at 9.7 million and annual rainfall of about 1100 mm. The water sources are shown in Figs.1 and 2

Fig.1.Geographical locations of fresh water reservoirs in Chennai metropolitan area. The deep borewell aquifer fields are also shown

Fig.2. Geographical location of the distant fresh water reservoir of Chennai

These reservoirs and fed by the monsoons of north east (N E) from August to October and south west (S W) from May to July. However, failure of monsoons reflect droughts which in 1993 became acute that piped water supply was turned off and the limited water availability was tankered door by door and individual borewells at homes inviting seawater intrusion.

2 The Storages of the Reservoirs.

No.	Name	Distance (x) km	Monsoon	Storage Mcft (xx)	Status
1	Poondi	30	N E	3231	Catchment & Transit
2	Cholavaram	15	N E	881	Transit
3	Red Hills	8	N E	3340	Catchment & Terminal
4	Chembarambakkam	within city	N E	3645	Catchment & Terminal
5	Veeranam	235	S W	1465	Stand alone
			Total	12562	

(x) From periphery of Metro limit
(xx) Million Cubic feet (the unit used in official records pan India)

3 Factors Influencing the Dependability of these Reservoirs

3-1 The Monsoon Failures

The reservoirs 1 to 4 are interlinked by open unlined earthen canals and are to be treated as a combined storage with influence of the North East (N E) monsoon with partial failure of close to once in four years and near complete failure in recent times in 1987, 1993 and 2015. Even otherwise, the variation over the past century is almost sinusoidal as in Fig. 3 and the peak and valley at about 700 mm and 300 mm per annum. The lower value of rainfall mostly goes into soil wetting and does not contribute to any appreciable run-off from the catchment.

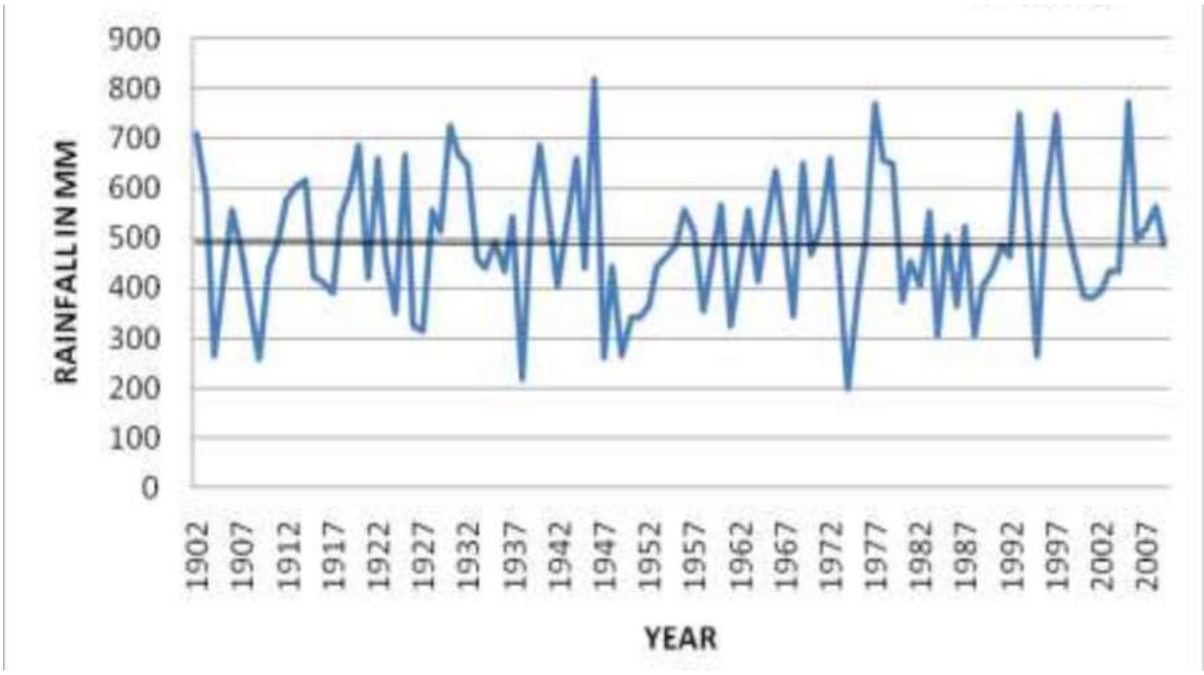

Fig. 3 North East Monsoon Annual Rainfall in mm over Chennai for 1902 to 2007 (1)

The reservoir 5 is fed by surplus of another inter-state river basin, called the Cauvery and is in the continual court room and tribunal contests between Tamilnadu and the adjacent Karnataka state which controls the origin of this Cauvery River flows released to Tamilnadu. Thus, the dependability of all these 5 reservoirs for a 24*7 public water supply is not there and for a metropolitan city it can at best be compared to walking on stilts.

3-2 Amelioration Factors bailing out the City Water Supply

As in Fig. 1, there is a nearby aquifer supporting drawal of water through deep borewells close to some 80 MLD at best, used historically to supply mainly the cooling water make-up of the Petro Chemical Industries which has been replaced by reusing treated sewage. The other factor is two Seawater Desalination plants of 250 MLD which produce water at close to Rupees 50 per kilo Litre but charged to the public at just about Rupees 7 only. Yet another factor is the inter-state agreement with neighboring state whereby water from the S W monsoon fed Krishna River there is to be sent to the Poondi reservoir in Chennai for an equivalent of 12000 Mcft, but this again is influenced by the vagaries of the S W monsoon.

4 The Reality and the Mirage of Assured Water Availability

Thus, the sustainability of public water supply from freshwater sources are under constant stress from vagaries of N E monsoon, S W monsoon in adjoining state and a heavy subsidy of cost of production vs sale of seawater desalination. Clearly, this position will only throw up more fissures in the future considering the ever growing water needs of this metropolis.

To illustrate this point, the daily water requirement even at a conservative per capita supply of 140 liters (which is the Indian national standard) works out to 1400 MLD. The availability from the best storage of 12562 Mcft in reservoirs translates to 960 MLD but the evaporation loss is close to some 60 % and hence actual “point of use” becomes 390 MLD only.

The agreement with neighboring state theoretically will account for about another 12,000 Mcft or 900 MLD but then, the logistics of storage of that water in a couple of monsoon months in existing reservoirs is a see-saw from the fact that the S W monsoon would cease by August and N E monsoon sets in October to December. Typical pictures are in Figs 4 and 5

Fig 4. Red Hills Reservoir when full

Fig.5 Red Hills Reservoir in Monsoon failure when scare water is pumped into the otherwise gravity intake.

5 The “Bird in Hand is worth Two in the Bush” Syndrome

This is an age old saying and has stood the test of wisdom of centuries. With the predictions of “water wars” in this century and with the near mirage of a wishful thinking of both physical and financial costs as discussed above, the once used and thrown away sewage is the “bird in the hand”. Instead of waiting for the Windhoek situation to dawn, Singapore in similar predicament has tested, piloted and implemented the indirect potable reuse of sewage in recent times. The line of such reuse is in Fig.6 and the treatment itself is in Fig.7

Fig.6. The NeWater chain at Singapore. It may be seen that advanced treated sewage is reused partly for industries and partly for letting into the fresh water reservoirs and the excess alone is let into the sea (2)

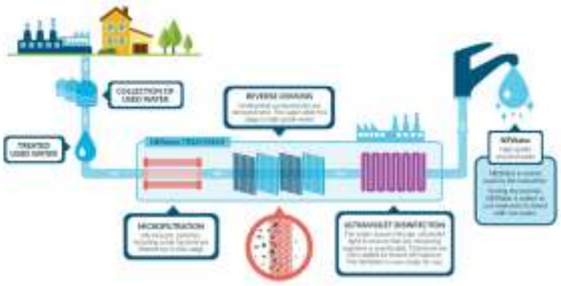

Fig.7.The treatment scheme for sewage as practiced for NeWater in Singapore.(2)

The "bird in the hand" argument lies in the fact that Chennai is long back in precedence to Singapore in effecting a similar treatment as in Fig. 7 even in 1992 in 2 plants of 12 and 17.5 MLD each and 2 more of 40 MLD each in 2020. Selected pictures are in Figs. 8 to 11

Fig.8.The 1992 photo of the second author in his then official capacity at the sewage reuse plant of Madras Fertilizers explaining the feautures to the then Director of the World Bank on his visit to the plant (3)

Fig.9.The 1992 photo of the second author demonstrating the drinkability of the treated sewage to the Director of the World Bank, the India Director, Chairperson and Managing Director of Chennai Metrowater (3)

Fig.10.The recent 40 MLD tertiary treatment and advanced filters and membranes buildings

Fig.11.The drinkability of recovered water demonstrated by the Honourable local Minister for water supply in Nov 2019 (4)

It is thus verified that the technical capability of treating sewage to this high standard is well established at Chennai for 30 MLD as early as 1992 and another 90 MLD added in 2020 totaling to 120 MLD. The only issue is all the treated sewage is being supplied to the industries and the implementation of the Singapore NEWater model of re-routing to supplement the fresh water reservoirs during droughts. This has not yet been pursued here, but it is a distinct possibility if the Veeranam reservoir as in Fig.2 is brought into play.

6 The Social Feasibility of Veeranam Reservoir Augmentation.

In all these reuse projects social acceptance is the key to the eventual success. It is more so when it comes to public drinking water supply, world over. In the case of Singapore, it was piloted by then prime minister himself demonstrating the drinkability as in Fig.12.

Fig.12. Singapore Prime Minister Goh Chok Tong Endorsing NeWater (5)

This was followed by an international expert group in engineering, biomedical sciences, chemistry and water technology. They found that NeWater's quality was consistently safe and high and well within the WHO and USEPA's requirements for drinking water and recommended for indirect potable use to be introduced into raw water reservoirs and the blended water to undergo naturalisation and further treatment in conventional waterworks to create public drinking water. This was followed by public knowledge dissemination and acceptance for topping up NeWater in their fresh water reservoirs during dry spells. In the case of Veeranam reservoir, there are no agricultural offtakes or public water supply use. Moreover, there are times when the reservoir bed is used as a cricket ground by local children. If and when the reservoir overflows, it only goes to the Bay of Bengal. As such, there are no competing demands from this reservoir and this reinforces the distinct potential for Social acceptance to be exploited.

7 The Engineering Feasibility of Veeranam Reservoir Augmentation.

The fresh water from the reservoir is put through a conventional water treatment plant consisting of screening, coagulation, flocculation, sedimentation and Rapid Sand Filters and chlorinated before being pumped to Chennai city over a distance of 235 km by a steel pipeline varying in a diameter from 1500 to 1875 mm diameter along the National Highway and has been in operation since 2004. At the other end, the Koyambedu advanced sewage treatment plant in Fig. 10 is located close to this highway and laying a pipeline alongside of the existing main to retrace the route of treated sewage to the reservoir is possible on the road margin without land acquisition matters. The question will be a pipeline cannot be re-laid all the way as and when more quantity of water is to be transmitted incrementally based upon the success of the piloting. This is got over by designing the pipeline for the maximum quantity but installing the forwarding pumps incrementally. These are fairly simple engineering.

8 Conclusions

Refusing to take note of an impending scarcity especially in public water supply can be catastrophic and lead to water supplies on alternate days or once in four or five days. This has been the case already. More serious is not to step out with piloting known and proven elsewhere solutions. The Chennai situation seems to offer a lasting and self sufficiency position if the potential of augmentation of the distant Veeranam stand alone reservoir by selective augmentation with advanced treated sewage is piloted on the lines of the Singapore NeWater. The Social feasibility does exist as this reservoir is not used locally for any other competing uses. The engineering feasibility exists by way of laying another pumping main alongside the existing main and there are no right-of-way or cross drainage challenges and incremental throughputs can be achieved in the same pipeline by incrementing the pumping capacities. Having demonstrated to treat city sewage to drinking standards in 1992, it is a paradox how Chennai has conceded Singapore to overtake this prospect even after 13 years.

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