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REUSE OF ADVANCED TREATED SEWAGE FOR SEAWATER INTRUSION BARRIER - A CASE STUDY

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ABSTRACT

It is well known that potable water is one of the very much essential domestic needs for people. The need is increasing day by day as the population increases. Although several methods are available to treat sewage for production of potable water, each method has its own merits and limitations. This paper describes a case study made for Chennai city, India to convert sewage in to useful water. Orange County model (California) has been adopted for reuse of advanced treated sewage. The disposal of R O reject can be a deep sea disposal because the feed to R O itself is sterile. The cost of this additional treatment will be just about Rs. 20 per 1000 liters at best. Over a period of time, nearly all the treated sewage can be recovered from inland as extracted water and from a location where it is needed because the aquifer is spread across the metropolitan region vastly.

Key words: Ogee spillway, Stepped spillway, Roller bucket, Energy dissipation.

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1. INTRODUCTION

Chennai, the capital city of Tamil Nadu, is located at the North east of the state. Apart from being a major district, this metropolis also serves as the gateway of South India. General information about Chennai reveals that of late, the city of Chennai has developed as one of the cosmopolitan cities in India that plays an important part in the cultural, intellectual and historical growth of India. The temperature is rising as summer nears and Chennai is staring at an alarming water crisis. Officials are struggling for a solution to fast depleting sources of water. A drop in levels at Andhra Pradesh's Kandaleru reservoir is a particular source of worry. Supply of Krishna river water from the Kandaleru reservoir via the Poondi reservoir - that the city is now mostly dependent on -has dropped from 400 cusecs (11,300 litres per second) to 120 cusecs (3,400 litres per second) over two weeks. This has resulted in shortage of drinking water supply in most parts of the city , barring core areas like Triplicane, Royapettah, Kotturpuram, Nungambakkam and Anna Nagar.The city's four main reservoirs, at Poondi, Red Hills, Cholavaram and Chembarambakkam, are dry or drying up fast. They currently hold 1.7tmcft, as compared to 8tmcft at the same time last year. Three reservoirs, barring Poondi, have run almost dry and Metrowater officials estimate water in the dams to last till April. The city requires 1,100MLD (million litres of water a day) but sup ply has now dropped to 550MLD. The dead storage in Cholavaram is under threat of evaporation and officials are pumping water from the Poondi reservoir to Chembarambakkam and Red Hills for supply to the city.The Kandaleru reservoir discharges 1,500-2,000 cusecs (42,500litres-56,000litres per second) per day. "Krishna water inflow has "Krishna water inflow has reduced due to the fall in the Kandaleru reservoir levels," a PWD official at the Poondi reservoir said. The officials are not certain when the inflow will pick up. Metrowater will soon have to turn to alternate sources, draw around 180MLD through wells in the Paravanar riverbed, the Neyveli basin and agricultural fields in Poondi and Tamaraipakkam in Tiruvallur. The city will continue to receive 100MLD each from the desalination plants at Nemmeli and Minjur.

In view of the above, advanced methods are necessary to reuse treated sewage.

The Mirage of Chennai’s Sustainability in Public Water Supply

The status of demand Vs supply of potable water is listed in Table 1 for historical and futuristic positions for Chennai city and metropolitan area.

Table 1 The Public Water Supply Demand and Supply, in Million Liters Daily (MLD

No	Year	Water Demand	Water Supply	Shortfall
For the Core city of Chennai				
1	1950	142	97	45
2	1960	173	144	29
3	1970	247	178	69
4	1980	328	243	85
5	1990	384	153	231
6	2000	632	200	432
7	2010	702	559	143
8	2011	1009	705	304
For the Chennai Metropolitan Area				
No	**Year**	**Desirable**	**Maximum potential**	**Shortfall**
1	2011	1330	760	570
2	2021	1679	1410	269
4	2031	2118	1410	708
5	2041	2671	1410	1261

2. WHEREFROM WE GET THE WATER

- The Red Hills system entirely dependent on NE monsoon of Oct-December

- The distant Veeranam lake entirely at the mercy of neighbouring state
- The Krishna waters from another gracious neighbouring state
- Seawater Desalination Plants of 100 MLD in north and 200 MLD in south

3. AT WHAT COST

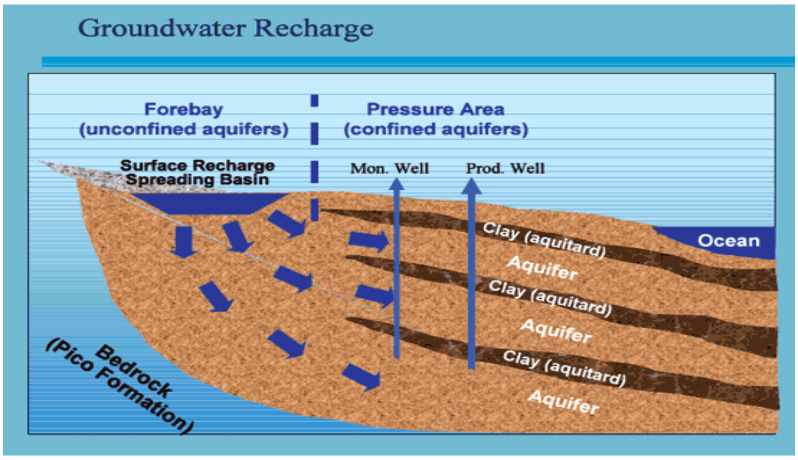
- Sources 2-1 to 2-3 cost Rs 4 per 100 liters and 2-4 Rs 50 to deliver into the pipeline.
- Weighted cost as of now is [(1110*4) + (300*50)] / 1410 = Rs 14 per 1000 liters
- Domestic tariff is about Rs 50 per month which equates to Rs 3.5 per 1000 liters
- About 10 % supply is for commercial users at about Rs. 100 per 1000 liters
- The shortfall for sustainability is Rs 10 per 1000 liters for 90 % supply
- This theorizes to Rs 1.3 crores per day as realistic shortfall for sustainability

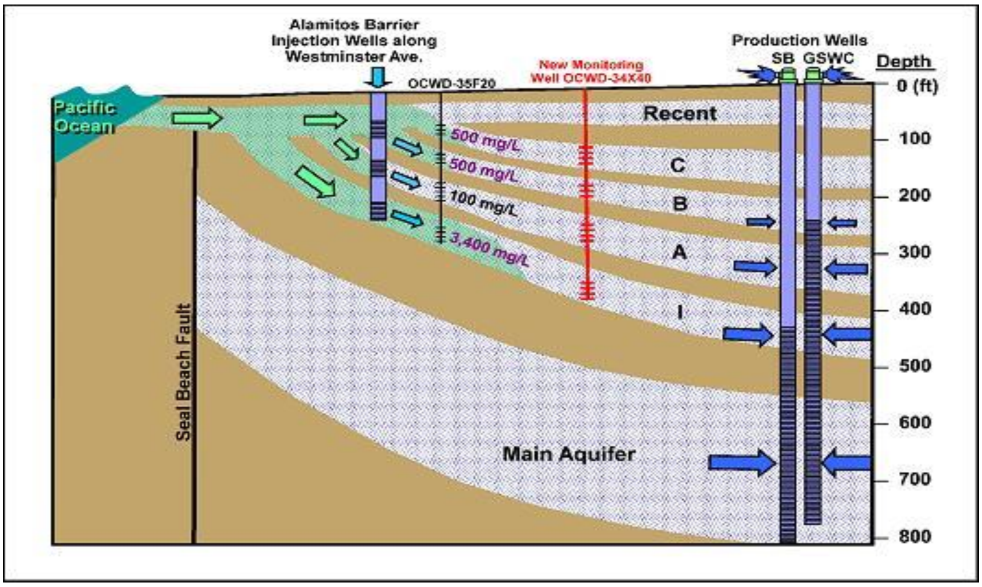
4. THE SEWAGE-A MISPLACED RESOURCE

- A small portion of 30 MLD of sewage is reused for industrial cooling in Manali
- All the other bulk of sewage is WASTED into the Bay of Bengal daily
- The days of pristine fresh water in rivers are all a bygone era
- Agra is putting up a sewage treatment plant to treat Yamuna river water
- It is this treated sewage that will be further treated and given as public water supply
- The mindset of treated sewage as anathema has to change

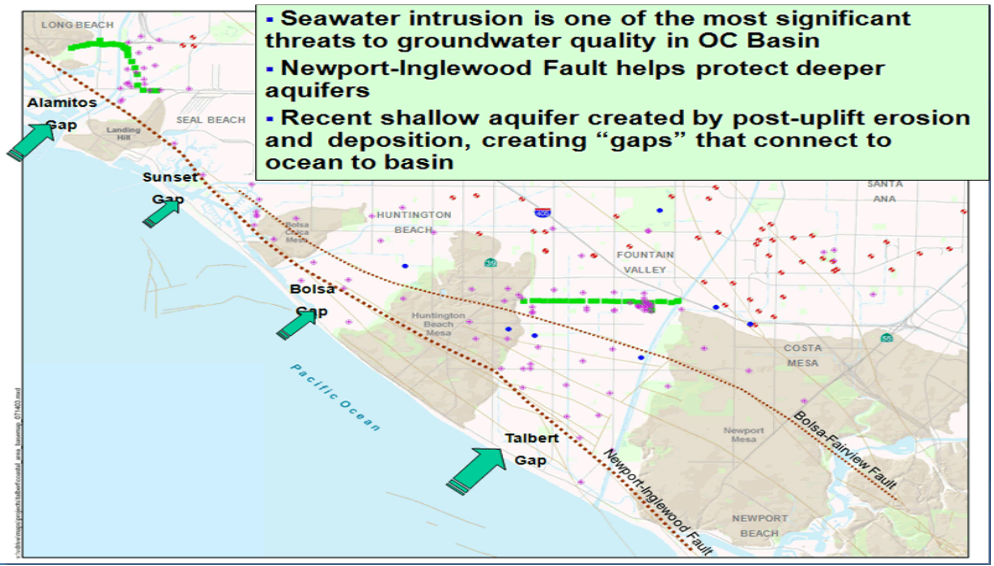
5. THE EXAMPLE OF ORANGE COUNTY IN CALIFORNIA

The case study of Orange County in California is an example in water judiciousness. Instead of making the freshwater as one-time use and discard, they have demonstrated that it can be a safe multiple reuse option and thereby freshwater can be allocated for superior uses only. The epoch making achievement started with a miniscule “water factory” where sewage was treated to an advanced degree and blended with extracted ground water and injected into deep well aquifers along the coast to firstly effect a seawater barrier against seawater intrusion and secondly to bring about a deliberate recycle through the aquifer media and thus becoming self sufficient in water needs. This effort of 1965 has since been expanded and currently the plant under completion is of the order of 300 MLD. This has been followed in Spain and other countries, notably in Israel. The schematic of Orange County is shown in Fig.1





(a) seawater intrusion barrier



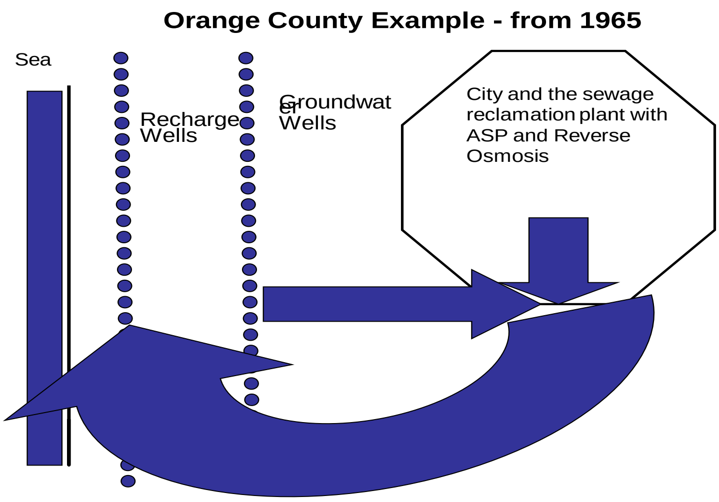


Figure 1 The Schematic of Orange County Advanced Treated Sewage Injection wells along the Pacific coast to achieve (a) seawater intrusion barrier & (b) indirect potable use of sewage

Statistically, the hallmarks of this project are as under.

- Rainfall 450 mm for 25 lakh people (Chennai 1200 mm for 50 lakh)
- Heavy reliance on groundwater
- By 1956, seawater intrusion 8 km inland
- By 1960, pilot studies for sewage reuse (Chennai studies 1965)
- By 1976, 23 wells 6 km inland injecting 82 mld blended water
- 18 mld RO permeate, 34 mld carbon treated, 30 mld deep well water
- The greatest advantage is it prevents land subsidence
- Nearby LA desert has undergone earthquakes thrice in 10 years
- Orange County has not experienced any earthquake

When the system was commissioned in 2008, it was and today remains the largest advanced water purification facility of its kind capable of producing 250 MLD of ultra-pure drinking water from highly treated waste water. This revolutionary system uses micro-filtration, reverse-osmosis and ultraviolet light with hydrogen peroxide to produce high quality water. Pharmaceuticals, pesticides and other harmful contaminants are removed and the water is pumped to recharge basins where it naturally filters into the groundwater basin, replenishing drinking water supplies. Using up to two thirds less energy than it would take to import water from Northern California and three times less energy than ocean desalination, the system produces enough water for nearly 600,000 residents at 400 lpcd (compared to our 100 lpcd) (Read more: http://www.digitaljournal.com/article/341692#ixzz3S9pFw3Dl)

6. INTERNATIONAL HALLMARKS IN SEWAGE REUSE

The has system has since been adapted at USA in Chanute, Whittier Narrows; South Lake Tahoe, Occonnan Virginia, Potomoc, Denver, Phoenix Arizona, Colorado Springs, Windhoek in Namibia, Cyprus and Van Houute in Belgium.

7. THE POTENTIAL AT CHENNAI

Nearly 85 % of the city sewage is treated in the treatment plants at Kodungaiyur in the north and Perungudi in the south. The Buckingham canal skirts these and cuts across the city on the coastline. Already the sewage is to be treated to BOD=20 and SS=30 standards at these two STPs. The nitrogen & phosphorous removal plus R O for removal of TDS from 1200 to 250 and disinfection for pathogens are all proven technologies in the country and are to be added. The disposal of R O reject can be a deep sea disposal because the feed to R O itself is sterile The cost of this additional treatment will be just about Rs. 20 per 1000 liters at best. Over a period of time, nearly all the treated sewage can be recovered from inland as extracted water and from a location where it is needed because the aquifer is spread across the metropolitan region vastly. More important, the required technology, equipments and manpower are all available within the country. The geographical depiction of the proposal is shown in Figure.2.

The water from Krishna &Veeranam is also subject to inter-state relationships and to that extent the availability from these sources are in turn subject to the monsoons. Considering all these, the utility of the proposed project is to be recognized at least now.

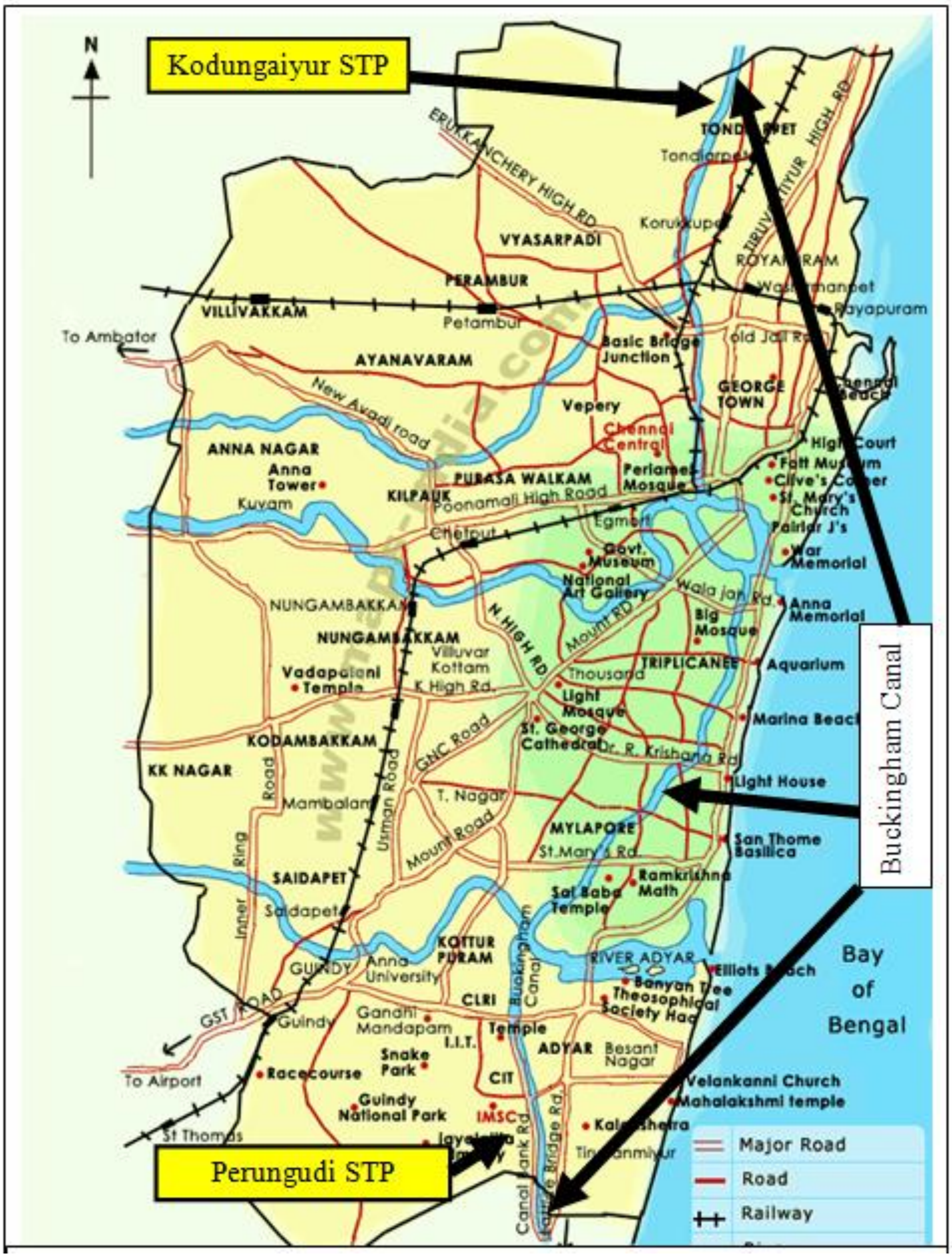


Figure 2 The Buckingham Canal enters Chennai from the north and exits in the south. It is a waterway and not a river, The 2 STPs are ideally located for a connecting pipeline between the two along the canal bank and for driving injection bore wells along the canal alignment parallel to the coastline and inject the treated sewage.

8. THE "MARKETING" OF THE CONCEPT

It is not as though this concept has not been thought off. The UNDP and W H O have carried out a project at Chennai from 1977 to 1987 for a soil aquifer treatment (SAT) in the north of Chennai where the secondary treated sewage from the nearby Kodungaiyur STP could be stored in SAT ponds and peripheral bore wells can extract the polished water for supplying to the petrochemical complex industries for non human contact type of industrial uses. Its implementation was negated as what was sought to be put onto the coastal ponds was direct secondary treated water and not sterile refined recovered water as in the present proposed project. However, with the proven use of this technology as of now and sterile water injection into the soil mantle, it should not be a problem to "market" it for public acceptance now.

9. CONCLUSION

A case has been made out for localized adoption of the Orange County model for reuse of advanced treated sewage for (a) seawater intrusion barrier and (b) help this metropolis from a water "famine" or perpetual water supply once in two or three days only for ever.

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REFERENCES

[1] A Decade of Sewage Reclamation, Kodungaiyur Sewage Reclamation Research Unit, Tamilnadu Water Supply and Drainage Board, Chennai, 1978

[2] Groundwater Replenishment System, Facts and Figures, Orange County Water District and Orange County Sanitation District, www.gwrsystem.com

[3] Second Master Plan for Chennai Metropolitan Area, 2026, Chennai Metropolitan Development Authority, September 2008

[4] Add references for Sewerage and STPs etc from CMWSSB public records

[5] Sundaramoorthy, S. and Nambi Ayyadurai.+ S, "Experiences in Reuse of Renovated Sewage as Industrial Cooling Water at Madras, India", Water Environment Federation, USA, Annual Conference, Anaheim, Session.58, Paper. AC93-058-005, October, 1993

[6] Sundaramoorthy, S. et.al. "Experiences in Sewage Treatment at Madras, India", Water and Environmental Management - Design and Construction of Works, Ellis Harwood Publishers, London, pp 453-465, 1991.

[7] Sastry C A and Sundaramoorthy S, "Industrial use of Fresh Water vis a vis Reclaimed Municipal Wastewater in Madras, India", International Journal of Desalination, 106, 1996, pp 443 – 448

[8] A Jawahar Thomas, Dr. S. Sundaramoorthy, Dr. M.P. Chokkalingam and Dr. S. Saktheeswaran, Concept Note On ZLD of City Sewage-A Tale of Two Cities - Orange County and Chennai - Explored, International Journal of Civil Engineering and Technology, 8(6), 2017, pp. 1061–1069.

[9] S. Sai Sree, SS. Aasdi and P. Polu Raju , Creation of an Integrated Optimal Urban Drainage Network Planning and Analysis of Chambered Sewage Treatment Plant: A Model Study From Part of Vijayawada, AP. International Journal of Civil Engineering and Technology, 8(4), 2017, pp. 1086 –1098