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Recycling, reuse, & economics of treated wastewater in urban India.

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Abstract:- **Sewerage & sewage treatment is a part of public health and sanitation. Out of total water supplied for domestic use around 70-80% gets generated as wastewater. To meet the severity of water crises, industrial & agriculture water demand, wastewater resource, its collection, treatment & reuse is very important alternative for fresh water. Treated wastewater has play an important role for industrial & Agricultural Water Demand, new urban growth area and has some economical advantages as a source of revenue for ULBs , potential to reduction Fertilizer use as used for irrigation & ground water pumping, has a potential of energy generation, reduces GHC emission & such project may implemented as CDM project. If projected estimates of wastewater generated in 2030 is considered and 80% of it is treated then 17 BCM of treated wastewater resource is available. This 17 BCM treated wastewater resource is equivalent to almost 75% of the projected industrial demand in 2025. Also almost a quarter of the total projected drinking water requirement in the country. For treated wastewater reuse project be successful there is some key design considerations that impact the viability of reuse projects such as tariff, quality & cost of treatment, cost of convenience, disposal of residuals. Present study has demonstrated municipal wastewater treatment, its potential for agricultural & industrial sector, treatment cost and other economics for sewage treatment, reuse & recycle initiative taken in various ULB is India.**

Keyword: Waste water treatment, technologies, reuse & recycle, treatment cost, tertiary treatment.

1. INTRODUCTION

Urban India faces significant challenges in terms of availability of adequate water supply and sanitation infrastructure. Water stress has become a perennial concern in most Indian cities and towns. It is often insufficient to meet the growing demand for water by all economic sectors. With a growing population, the per capita availability of water has dropped from 1,816 cubic meters in 2001 to 1,545 cubic meters in 2011.(1) The latest census reported that only 70% of urban households have access to piped water supply. The average per capita supply to these households is well below the recommended 135 liters per day in many cities. India is expected to add approximately 404 million new urban dwellers between 2015 and 2050. (2) The rapid urban growth will be linked with higher industrial output and greater energy demand. There is increasing water demand from households, industries and power plants and adding to the urban water stress. This is particularly visible in industrial metros such as Chennai, Bengaluru, and Delhi, where acute water shortage has driven up the cost of fresh water production and industrial water tariffs. To mitigate the severity of this impending crisis, there is a need for innovative alternatives to fresh water. Wastewater collection, treatment & reuse of treated wastewater or reclaimed water are one such alternative that is gaining revenue.

1. Ministry of Water Resources, Press Information Bureau (PIB), http://pib.nic.in/newsite/erelease.aspx?relid=82676
2. World Urbanization Prospects 2014, United Nations (UN), New York

II. WATER SUPPLY & SANITATION INFRASTUCTURE IN URBAN INDIA

Urban India is growing rapidly and this poses significant challenges for urban infrastructure and services like water supply, sanitation, solid waste management, wastewater collection and treatment, and drainage. Inadequate sanitation resulting in poor hygienic practices leads to huge economic and social losses for the country. WSP (2011) estimated that this loss is equivalent to about 6.4% of India's gross domestic product (GDP) in 2006. Collection, treatment and reuse of municipal wastewater provide an opportunity for not only environmental rehabilitation, but also meeting the increasing water needs of different economic sectors. In addition recycled wastewater becoming an additional and valuable water source, there is also having potential to recover nutrients and energy from wastewater. As per CPHEEO estimates about 70-80% of total water supplied for domestic use gets generated as wastewater. The per capita wastewater generation by the class-I cities and class-II towns, (representing 72% of urban population in India), has been estimated to be around 98 LPCD while that from the National

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Capital Territory-Delhi alone (discharging 3,663 MLD of wastewaters, 61% of which is treated) is over 220 LPCD. An estimate also shows from 723 of India's cities and towns, with populations of 50,000 and above, around 38000 MLD of wastewater is generated. In these towns, existing wastewater treatment capacities amount to only 31% of the wastewater generated. At least 67% of the wastewater generated from Class I cities and more than 90% of wastewater generated from Class II cities in India is not treated and is therefore a cause of environmental pollution and unavailable for beneficial and safe reuse of wastewater. With current population growth (1.7% per annum) and the current rate of urbanization (3% per decade), the urban population is expected to increase by more than 50% from 377 million in 2011 to 590 million by 2030 (MGI 2010), with a proportionate increase in the volume of urban wastewater, to nearly 60,000 MLD. If 80% of urban wastewater could be treated by 2030, there would be a total volume of around 17 billion BCM per year; an increase of around 400% in the volume of available treated wastewater .This additional 17 BCM of treated wastewater resource, if captured, treated safely and recycled, this is equivalent to almost 75% of the projected industrial water demand in 2025 (MoWR 2006) and almost a quarter of the total projected drinking water requirement in the country.

III. THE GROWING URBAN SANITATION CHALLENG

Urban India is also growing rapidly and this leads to number of challenges for the provision of urban infrastructure and services, like water supply, urban sanitation, solid waste management and drainage. While 87% of the country's urban population has access to household or community sanitation, the collection, treatment and disposal of wastewater is a cause for concern. Only one-third of all households are covered by sewer networks, with 47% of households relying on on-site sanitation systems. The low coverage is also compounded by the grossly insufficient treatment capacities in urban centers. According to the Central Pollution Control Board (CPCB), about 38,000 MLD of wastewater were generated in Class I cities and Class II towns in India (housing more than 70% of the urban population). The wastewater treatment capacity developed so far is only 11,788 MLD accounting for about 31% of total wastewater generated in these two classes of urban centers. The existing treatment plants are not utilized at full capacity and operate at about 72% utilization (CPCB 2009a). Consequently more than 75% of the wastewater generated in Class I and II urban towns and cities are discharged on land or in various water bodies without any treatment. It leads to large-scale environmental pollution and creating a health hazard for public. The discharge of untreated or partially treated wastewater on land or surface water bodies is a major source of pollution, contaminating 80% of the country's surface water (CPCB 2007).

IV. TECHNOLOGY OPTIONS & TREATMENT LEVEL

There are numerous technologies to treat wastewater. Sewage water is treated in stages to progressively improve quality of treated water. The most important water quality parameters in case of sewage are biological oxygen demand (BOD), chemical oxygen demand, total suspended solids (TSS), and nutrients (nitrates and phosphates). Treatment technologies for wastewater can be categorized based on the location where treatment is provided and the type of treatment provided. The location of the treatment system will make the management system either an onsite system, decentralized system or an off-site system requiring extensive underground sewerage to carry wastewater to the off-site treatment facility. Each of these systems has different geographical, demographical and financial conditions. Figure 1 illustrates the link between the levels of treatment, intended use of treated water, cost of treatment and extent of cost recovery. As level of treatment increases burden to service provider for capital costs and O&M costs increases ,with not enough revenue realization in the absence of demand for this high quality water.

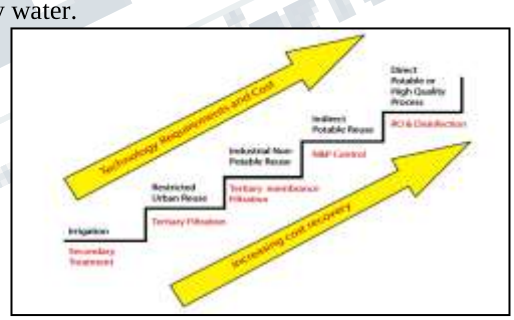

Fig. 1 Level of Treatment & cost recovery

An analysis by CPCB (CPCB 2012) estimated the typical treatment costs (both capital and O&M expenses) associated with different levels of treatment provided to wastewater. The analysis estimated that the cost of treating wastewater escalates rapidly when advanced treatment systems, such as membrane ultra-filtration (UF) and reverse osmosis are included. The annual treatment cost (including annualized capital cost and O&M expenses) increase from about INR 34/kL (USD 0.649) for conventional secondary treatment to about INR 52/kL (USD 0.97) when UF is added, which further increases to INR 73/kL (USD 1.37) when the water is also treated using a reverse osmosis module. The choice should be based on financial assessment of the investment

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required, customer profiles and their willingness to pay for the treated water.

The other significant classification criterion is the type of treatment provided – primary treatment, secondary treatment or tertiary treatment. Primary treatment essentially consists of removing the suspended solids present in the wastewater through physical sedimentation or coarse screening methods. Secondary treatment involves some form of biological treatment which removes the organic matter lowering the bio-chemical oxygen demand (BOD) of the wastewater. Primary & Secondary treatment objective is to sufficiently remove contaminants so that the effluent (referred to as STW) can be safely discharged into water bodies. Reuse/TTP project provides the most advanced level of treatment to further treat STW, reducing BOD and the total dissolved solids (TDS) levels to very low levels and can also effective in removing dissolved impurities and nutrients such as nitrogen and phosphorus that may be present in the water. The type of advanced treatment (nutrient removal/ reverse osmosis/advanced disinfection) will depend on the type of reuse application, and is usually significantly capital-intensive along with high O&M costs compared to conventional secondary treatment alone. The STW is used for agriculture in many peri-urban areas. However, for our defined purpose of industrial reuse, STW has to be tertiary treated to produce industrial grade water. The stages of treatment and the corresponding grades of industrial water produced are shown below:

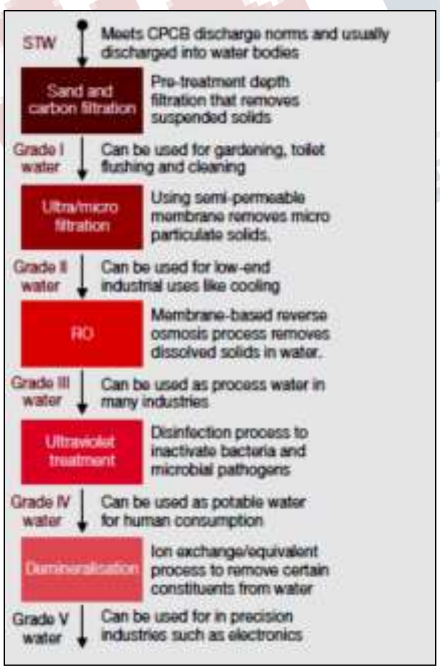

Fig 2 Classification of Gray Water

Stages of treatment and their specific uses are depending on factors such as quality of the influent (concentration of minerals, etc.) and treatment technology used at previous levels. For some of the treatment stages, more than one technology option is available. In such cases, reuse projects must choose the most cost-effective technology option, given the quality of the influent, to produce the desired quality of output. The demand profile for industrial water in the region and corresponding technology choices will determine the treatment cost. For the purpose of this paper, I have considered SBR, ASP as secondary treatment & sand filtration, microfiltration, and reverse osmosis, disinfection as major stages in the tertiary treatment process to produce industry grade reclaimed water.

V. ECONOMIC & FINANCIAL BENIFITS OF WASTEWATER RECYCLING & REUSE

Treated wastewater plays important role for providing a reliable source of water to meet industrial and agricultural water demand. Several countries have adopted recycling and reuse of wastewater to varying degrees and for a range of activities. Wastewater recycling can meet different water requirements, i.e., in industries, for irrigation in agriculture and also within urban areas for horticultural/municipal needs. Two significant users of recycled wastewater are industries and agriculture, as discussed below.

1. Wastewater Recycling to Meet Agricultural Water Demand

In India, the urban wastewater generated (estimated currently at about 38,000 MLD in Class I and II cities), if treated and channelled to meet agricultural irrigation requirements, would provide 14 BCM of irrigation water, which could potentially irrigate an area ranging between 1 to 3 million hectares (ha). While this quantum (14 BCM based on 2009 wastewater generation estimates) might not seem significant compared to the total irrigation water demand in 2025 (910 BCM according to MoWR estimates), its significance should be viewed in relation to the national efforts to increase area under irrigation during recent five-year plan (FYP) periods. During the 10th FYP period, the major and medium irrigation potential created was 4.59 million ha, while the surface water-fed minor irrigation potential developed was 0.71 million ha (MoWR 2011). The wastewater irrigation (WWI) potential (~2 million ha) is 44% of the major and medium potential created and nearly three times the surface water-based minor irrigation potential created in the 10th plan.

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2. Potential for New Urban Growth Areas

Recycling and reuse of wastewater is also as an integral component of the urban water and sanitation projects in new urban areas in some cities such as Jaipur, Rajasthan. As Ground water is the predominant source of water in most areas in Rajasthan, with 90% of rural and 80% of urban water supply schemes based on its exploitation. The state is experiencing progressive deterioration in the yield and quality of ground water to meet increasing demands. Out of 243 blocks in the state, 172 belong to the 'overexploited' category (2011 assessment). Jaipur has therefore embarked on a project to treat and reuse the wastewater generated in the city for use in industries, as well as for non-potable domestic applications such as flushing (through a dual piping system in all new urban growth areas under development). The projects are under development and detailed project reports for the scheme are in preparation.

3. Sale of Recycled Water – a Source of Revenue for ULB

ULBs, when operating well-managed STPs, are in a position to sell the treated effluent to industrial customers depending on the need for and availability of other water sources. They may charge industrial customers for supplying recycled wastewater based on the treatment provided and quality of wastewater. Experience from Chennai demonstrates that treated wastewater is being sold to industries at INR 8-11 KL-1 (USD 0.13 - 0.1823), and the resulting revenue generated through this sale is adequate to cover the O&M costs of the treatment plants. While several utilities supply treated wastewater to different industrial users, the reuse and sale of treated wastewater is largely anecdotal throughout the country. Following are some initiatives taken by various ULBs towards wastewater recycling and sale of treated wastewater.

4. Potential of Nutrients

Wastewater contains valuable nutrients (NPK), which may either be recovered as a resource or recycled when treated wastewater is reused for irrigation or other applications. When using treated wastewater for irrigation, these nutrients aid crop growth and could reduce the need for synthetic fertilizers in India by up to 40%. Nevertheless, wastewater is a valuable source of plant nutrients and needs to be viewed as an economic resource by the planning authorities at national, state and local levels. In its review of wastewater generated in the coastal cities in India, the Central Pollution Control Board (CPCB 2009a) estimated a nutrient load of 347.56 tones day in about 6,400 MLD of wastewater generated from these cities daily (the treatment capacity against this is about only 3,050 MLD, which is about 47% of the total wastewater generation). Several other studies have also estimated the nutrient potential in wastewater is ranges from 0.054 to 0.073 tones. When valuing the nutrients present in wastewater, it is important to also consider other constituents which may impact suitability when reusing treated or untreated wastewater in agriculture. The high salinity of wastewater is of particular concern, as there may be short- to long-term effects on the salinity of soils and river water receiving treated wastewater. The impact on agricultural produce will depend on the exact nature of wastewater and the salinity thresholds of the crop being cultivated.

5. Reduction in Fertilizer Use

The availability of affordable fertilizer is critical to the performance of the agriculture sector in India, which is heavily dependent on government subsidies on agricultural fertilizers. Indian soils are generally lack in both K and P. Therefore the country has to depend upon imports (100% potash and around 90% phosphate) for meeting these fertilizer needs. Urea (a source of N) is the only fertilizer which is produced in India and can meet a significant share (about 80%) of the indigenous requirement. The fertilizer subsidy burden for the central government in 2012-2013 was about INR 700 billion, and study forecasted it is expected to double by the end of the 12th FYP in 2016-2017. But by Use of treated wastewater and sludge for agriculture has the potential to reduce reliance on fertilizer by about 40% in areas irrigated with treated wastewater due to its inherent nutrient content. As of now the budgeted estimates for fertilizer subsidy in 2017/18 budget is remains unchanged. (About INR 700 billion).Based on current wastewater generation, irrigation potential estimated for wastewater in India and the associated potential to reduce fertilizer consumption in wastewater irrigated areas, it can be estimated that the annual fertilizer subsidy could be reduced by about INR 1.3 billion.

6. Increase in Overall Farm Income

There are some analysis in various studies which shows increased economic benefits for farmers engaged in cultivation with treated and untreated wastewater compared to freshwater, due to increase in yields, lower fertilizer requirement and improved quality of yield resulting in higher prices for the produce. an increase of about 30% in the farmers income has been achieved in some cities in India compared to when the farmer uses freshwater alone. Considering the average landholding size in India of about 1 ha, & channelling the entire amount of treated wastewater towards agriculture which shows potential to support 2 million farmers and increase their annual farm earnings by INR 17,000 ha/year or about 30% over the baseline levels.(using freshwater alone).

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7. Reduction in Ground Water Pumping & energy requirement Due to Wastewater Irrigation

As per IDFC report more than 60% of the country's irrigation requirements are met by ground water, which requires energy intensive ground water pumping. If the entire amount of wastewater generated in urban areas can be channelled towards irrigation then potential of around 5 % of ground water irrigation is reduced. Reduce ground water requirements in these areas leads to a reduction in associated energy use. With the availability of a continuous supply of wastewater, reliance on ground water extraction could be reduced. Considering the substitution potential of wastewater irrigation and assuming a reduction of pumping use by at least a third of the current use in these wastewater-irrigated areas, the savings in grid electricity supply requirements would be significant and are estimated to save (the state government and the electricity utility) about INR 6 billion (USD 128 million33) annually.

8. Greenhouse Gas Mitigation from Use of Treated Wastewater for Irrigation

Wastewater use for irrigation reduces energy requirement for pumping. As this Conservation of energy has the concomitant benefit of reducing harmful GHG emissions that would have been generated during the production of an equivalent amount of electricity using fossil fuels. estimate suggests that avoided ground water pumping has the potential to reduce about 1.75 million MWh of electricity annually, which is equivalent to reducing about 1.5 million tonnes of CO 2e (tCO2) GHG emissions. There is significant scope to create additional income streams for treatment plant operators through the Clean Development Mechanism as recently proposed for China (GTZ 2009).

VI. MARKET POTENTIAL FOR REUSE

In India two major trends of this era are industrialization and rapid urbanization. As the industrial footprint expands, the demand for energy and water grows. It is estimated that, between 2010 and 2050, the energy sector's water demand will grow by 3.7 times and that of manufacturing sector will grow by 2.2 times. The projected growth in industrial water demand is presented below:

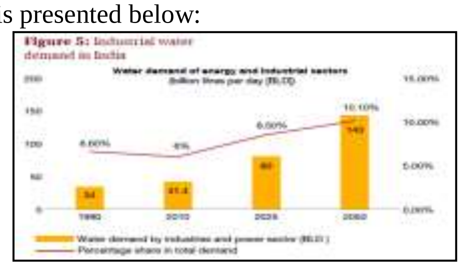

Fig 3 Industrial water demand

If we consider the annual utilizable freshwater remains the same over the next 33 years, water available for the industrial and energy sectors, after accounting for the growing human demand, will drop from 491 billion cubic meters to 135 billion cubic meters in 2050. So reuse of reclaimed water will then be the most reliable source of water for these sectors. Wastewater recycling is beneficial both for utility and industrial customers to meet some part of their industrial water needs, depending on processed water quality considerations. Industrial customers now are also in a position to adequately pay for the use of treated wastewater. MoEF and CPCB assessment (CPCB 2009) undertaken to assess the status of environmental pollution across various industrial clusters in India identified a total of 88 industrial clusters spread across 21 states. Within these 88 industrial clusters it may be possible to recycle about 36 % of wastewater (wastewater generated across all Class I and Class II towns in India) for industrial reuse. As discuss above in abstract, recycled wastewater from Class I and II cities has the potential to meet about a quarter of the total current industrial water demand (17 BCM including demand for energy). However, this entire water demand will not translate into demand for reclaimed water. In order to service this demand using reclaimed water, there is a need to address some key design considerations that impact the viability of reuse projects. These include availability of treated water in the vicinity of industrial areas, access to alternative water sources, water tariff, and conveyance distance, which will add to the capital and operations and maintenance (O&M) cost of reuse projects and also impact water tariff at the industry gate. Some of this key viability are discussed in the following section,

VII. VIBILITY CONSIDERATION

or reuse projects to be successful, the following are some of the key viability factors that need to be considered during project design and structuring:

✓ ***Water tariff***

Success of reuse project is depends on cost competitive when compared to alternative options available to industries. The most reliable option for industries is municipal water supplied by utilities. Industrial water tariff in most large cities is typically quite high as industrial tariff s are set high to cross subsidize drinking water. For example, Chennai's industrial water tariff is Rs 60/KL whereas the domestic water tariff is just Rs 4/KL. According to report, industrial tariff's across the larger cities are typically above Rs 45/KL.

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Trends in water tariff for industries are as shown in fig. 4.Given the range of treatment costs described earlier, it appears that ULB could afford to provide STW at below the current industrial tariff.. In times of water scarcity, when municipal water is in short supply, industries are buying water from private water tankers which are priced on lump-sump basis and depends upon case to case.

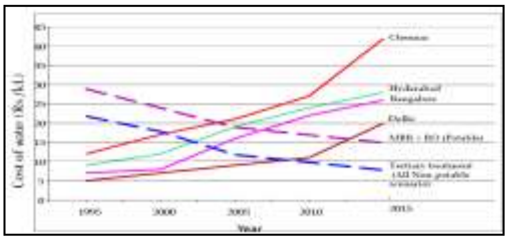

Fig 4 Industrial tariff

✓ *Quality & Cost of reclaimed water*

An estimated variation in costs of reclaimed water based on levels of treatment is presented below.

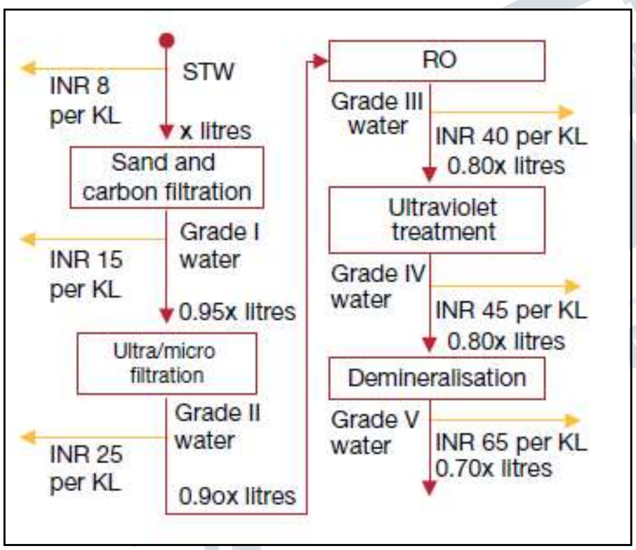

Fig 5 Cost of treated water.

Above estimates include capital and operating costs of the treatment facility but do not include cost of conveyance. In addition to the incremental costs associated with higher levels of treatment, the volume of reclaimed water also decreases as we move through the stages and this directly affects the revenue potential of reuse projects. For example, for 100 liters of STW supplied, up to 80 liters of Grade III water is produced after reverse osmosis. It is not economical to lay multiple pipelines to supply different grades of water. A single treatment level must therefore be chosen upfront when designing reuse projects with multiple users, and demand for water at this quality level should be assessed. If conveyance costs are covered by end users, or if water is purchased at plant gate, then it may be viable to produce different grades of water quality.

✓ *Cost of conveyance*

The conveyance of STW to reuse plants and reclaimed water to industries requires underground pipelines. In addition, to underground pipeline cost further costs will be incurred for the O&M of the pipelines. These high costs erode the cost advantage of reclaimed water over standard piped water supply from the utility. Land gradation between the treatment plant and customers is another determinant of the overall cost of conveyance of reclaimed water to industries. This total convenience cost is very difficult to recover through customer tariff while keeping the tariff lower than the standard rate for industrial piped supply. Despite these issues, there are advantages in bundling treatment and conveyance components, as it is easy to design and manage, and helps ensure quality and continuity of service.

✓ *Quality of STW*

The composition of sewage generated and collected by a secondary treatment plant, and the quality of secondary treatment process is another variable that affects the viability of reuse projects. Under ideal conditions, municipal sewage collected from households is a homogeneous influent. But given the inadequate sewerage network, and other related factors sewage is often mixed with industrial waste from small-scale industries such as tanneries and dyeing units. This adds high chemical load to sewage and affects the composition of the influent to STPs. As a result it require more expensive treatment at the tertiary level to produce industry grade water. The quality of secondary treatment process in municipal plants is also not consistent. Most STPs are not designed to manage peak flows, leading to overflows and contamination of treated water by untreated sewage. Poor design, power shortages, lack of O & M, and mismanagement by operators also lead to STP downtime, resulting in variable effluent quality. This in turn has cost implications for the reuse plant, which uses the STW as an influent; with add-on effects on operating and potential capital costs. One way of ensuring more consistency in STW quality would be to bundle O&M of the secondary plant into the reuse contract. This also entails risks as variation in the composition of raw sewage, design issues and the difference in capacity between the STP and the reuse plant will mean that it is difficult to recover the STP O&M cost through the reuse tariff. A separate O&M cost could be paid instead to the company that operates both STP and the reuse plant.

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✓ ***Disposal of residual effluent***

In reverse osmosis process the residual wastewater produced is account for 12-15% to that of total STW treated and it consist of very high concentrations of unwanted compounds and microbial load. This residual output does not meet environmental discharge norms of the CPCB. The safest method of disposal is through a marine discharge or evaporative watering. The cost of disposing it will in turn depend on the distance from the marine discharge area and dewatering technology used. The viability of reuse projects in non-coastal cities will depend on cost of disposal of residual effluent.

VIII. ECONOMICS OF TREATED WASTEWATER

Following are the some of the initiative taken by some ULB in India for sale of treated water to industries,

1. Delhi supplies treated sewage to industrial establishments like power plants, industrial areas and hospitals. The Delhi government gave an option to Pragati Power Corporation Limited (PPCL) to operate two of the DJBs 20 MLD STPs to meet its water requirement. The current O&M cost incurred by PPCL stands at about INR 4 kL(USD 0.075). The Delhi Jal Board (DJB) has also evaluated technologies to retrofit the existing 113 MLD portion of the Okhla sewage treatment plant (STP) for recycling and reuse of wastewater for non potable applications in the nearby industrial units.

2. The Bangalore Water Supply and Sewerage Board (BWSSB) is one of the few agencies involved in tertiary treatment of wastewater and supplying the same to nearby industries/plants. Currently, four of the seven STPs undertake tertiary treatment. The average cost of tertiary treatment comes to about INR 10–15 kL (USD 0.19 – 0.28). Bengaluru charges INR 60 kL (USD 1.12) for freshwater to be used for industrial purposes. BWSSB supplied treated sewage to a number of industries, Bengaluru International Airport, Bharath Electronic Limited, Indian Tobacco Company, Rail Wheel Factory and Indian Air Force. BWSSB has initiated a scheme on the Integrated Water Resource Management Reuse of Wastewater from Vrishabhavathi Valley (V Valley). It consists of a 135 MLD reuse process scheme to be undertaken in four phases. The landed cost of high quality treated water from V Valley to River Arkavathy will be INR 12 KL(USD 0.22).

3. The Surat Municipal Corporation (SMC) is also supply treated wastewater to industrial units in the Pandesara Industrial Estate. The SMC is also developing a 40 MLD tertiary treatment plant at Bamroli on a PPP basis. the cost of procuring freshwater from the current level of INR 22 kL(USD 0.41) for industrial use. In addition, cities like Hyderabad, Nagpur and Pimpri– Chinchwad are also undertaking initiatives to promote the use of treated wastewater. Hyderabad is planning to implement a project to recycle wastewater at its three major STPs (Amberpet, Nagole and Nallacheruvu) and supply it to industries. Recently, the Japan International Cooperation Agency (JICA) gave its approval for providing financial assistance to the project. HMWSSB charges INR 1 kL(USD 0.019) for treated water available for reuse.

4. The Gurgaon District Authority has made it mandatory for all construction firms to use treated wastewater from its STPs for construction and other non potable purposes. The Authority has started supplying tertiary treated wastewater from two STPs – Behrampur (15 MLD) and Dhanwapur (25 MLD) at a rate of INR 4 kL (USD 0.062).

5. The Jaipur Municipal Corporation has implemented an Asian Development Bank (ADB)–funded STP in Delawas. The treated wastewater from the 62.5 MLD STP is supplied to nearby small–scale industrial units and for irrigation purposes. Also, the sludge generated is used as manure for agriculture and nursery purposes. The STP was commissioned in September 2006.

6. Chandigarh municipality charges INR 500 acre (USD 7.81) for supplying treated wastewater to be used for agricultural irrigation and charges INR 50 kanal (USD 0.7874) (500 yards2) month for irrigation of green spaces.

7. Chennai Metro Water (CMW), the water supply and sanitation authority in Chennai, uses secondary level ASP plants to treat its sewage slightly beyond CPCB standards for freshwater discharge. Out of 740 MLD of STW currently produced CMW sells 36 MLD to three large industries located in the north of the city. The STW is sold for Rs 10.20/KL and includes the cost of pumping the STW to the plant gates. An average O&M cost for collection and treatment across all its plants is Rs 8.90/KL. The O&M cost of treatment alone is estimated to be approximately Rs 4.08/KL. Also CMW's four newest plants are completely powered by internally generated biogas for nine months of the year that reduces its electricity costs by about Rs 0.45/KL.

8. The CPCL plant in Chennai encountered acute water shortage and scarcity of supply in the wake of severe water

shortages in the city. CPCL set up a wastewater recycling plant to treat partially treated wastewater from the water utility. The cost of recycled wastewater to the industry is INR 45/KL (USD 0.70) compared to INR 60/KL (USD 0.70) for the water purchased from the water utility.

9. The City of Nagpur (Nagpur Municipal Corporation (NMC)) has entered into an MoU with the Maharashtra Power Generation Company Limited (Mahagenco), a public sector company, for “Construction and Operating Agreement of Treatment and Transmission Facilities for Reclaimed Water Usage”, whereby NMC will provide 110 MLD of untreated, raw sewage to Mahagenco at the rate of INR 15 crore/year (USD 2.8 million46), will allocate land at no additional cost to the company .The treatment cost to Mahagenco about INR 3.4 m-3 (USD 0.05), which would have been significantly higher if the company had decided to source freshwater from municipal or irrigation command project (about INR 9.6 m-3 (USD 0.15).

In the absence of available tertiary treated STW, some industrial units have chosen to buy either raw sewage or secondary STW and treat it further to meet their water purity requirements. For example, Madras Fertilizers Limited (MFL) in Chennai and Rashtriya Chemicals and Fertilizers Limited (RCF) in Mumbai are purchasing STW and raw sewage, respectively from their local water authorities. MFL utilizes 60 per cent of its water at the tertiary treatment level while 40 per cent is sent for RO and DM. RCF uses 73 per cent at the RO level and 27 per cent at DM stage. Stage-wise cost of treatment is given in Table I. In the case of MFL, it is actually cheaper to use STW than freshwater both because of the high industrial water tariff in Chennai and because it is more expensive to dematerialize freshwater than tertiary level STW. In the case of RCF, while there is a minimal price difference between RO level water which is used interchangeably with fresh water, this is weighed against having a reliable supply of water and control over quality which is highly valued by these kinds of industries.

TABLE I
STAGE WISE COST OF TREATMENT

	MFL		RCF	
	STW	Fresh water	STW	Fresh water
At plant Gate	10	60	0.60	40
At TTP plant	28	130	NA	Not Req.
At RO	70	Not Req.	45	Not Req.
At DM	100	Not Req.	100	100
Avg. Treat. cost	57	88	60	56

IX. COST COMPARISON FOR VARIOUS TECHNOLOGIES FOR SEWAGE TREATMENT PLANT.

CPCB has done performance evaluation of sewerage treatment plant under NRCD. The report envisages for 152 STPs spread over 15 states in the country and having total treatment capacity of 4716 MLD. Following are the cost comparison of various technologies for sewage treatment.

TABLE II
COST COMPARISON FOR DIFFERENT TECHNOLOGIES

Parameter	ASP	MBBR	SBR	UASB +EA	MBR	WSP
Capital Cost						
Average Capital Cost (Sec.Treat.), lacs/MLD	68	68	75	68	300	23
Average Capital Cost (Tert Treat), lacs/MLD	40	40	40	40	40	40
Total Cap Cost (Sec + Ter),	108	108	115	108	300	63
Civil Work, % of total cap costs	60	40	30	65	20	90
E & M Works, % of total capital costs	40	60	70	35	80	10
Area Requirements						
Average Area, m2/MLD Sec.Treat + Secsludge handling	900	450	450	1000	450	6000
Average area, m2/MLD Tert. Treat. + Tert Sludge Handling	100	100	100	100	0	100
Total Area,	100	550	500	1100	450	6100

m2/MLD Sec + Tert treatment	0					
Energy Costs (per MLD)						
Daily Power Req. kWh/d/MLD Sec+ Sec Sludge	180	220	150	120	300	2
Parameter	ASP	MBBR	SBR	UASB +EA	MBR	WSP
Daily Power Req, kWh/d/MLD Ter + Tert Sludge	4.5	2.5	2.5	4.5	2.5	2.5
Total daily Power req. kWh/d/MLD	185.70	223.70	153.70	125.70	302.50	5.70
Daily Power Cost (@ 6.0 per KWh), MLD/Day (including Standby power cost)	1114.2	1342.20	922.20	754.20	1815	34.2
Yearly Power Cost, pa/MLD	4.07	4.90	3.37	2.75	6.65	0.49
Repairs Cost /MLD						
Civil Works Maintenance, pa/MLD	1.94	1.3	1.04	2.11		1.7
E & M Works Maintenance, pa/MLD	0.43	0.65	0.81	0.38		0.06
Annual repairs costs, pa/MLD	2.38	1.94	1.84	2.48		1.76
Chemical Cost						
Recurring Chemical/Polymer Costs, pa/MLD Sec Treatment	0.4	0.4	0.4	0.4		
Recurring Chemical, pa/MLD (Alum, Chlorine, Polymer) Costs, Tert. Treatment	4	4	2	5		6
Total Chemical Cost, pa/MLD	5.3	5.3	3.3	6.3		7.2
Manpower Cost (Assuming 50 MLD Plant)						
Salary + Benefits pa	42.12	30.96	25.92	42.12		32.04
Annual O & M costs Lacs/MLD	11.75	12.14	8.51	11.53		9.45
Total O & M costs /annum (For 50 MLD)	629.26	638.11	451.22	618.96	832.55	504.86

X. CONCLUSION

Based on the all above observation it needed to promote reuse of treated wastewater. for this Central and state governments should jointly issue a national wastewater reuse policy with clear policy targets, setting out the legislative, regulatory and financial measures needed to achieve those targets. Also, the Ministry of Environment and Ministry of Water Resources should together define quality norms for different grades of industrial water which will help standardize design of reuse systems nationwide. National level norms for water safety planning and risk management are also needed to build credibility for reclaimed water as a reliable alternative. At first stage it is necessary to produce city level urban wastewater reuse plan, followed by detailed feasibility studies for individual projects. Project also includes compiling justification based on detailed industrial water demand assessment. This demand study would also help to define the level of treatment required and other design aspects involved. There should be a jointly wok between ULB SPCB & state industrial development corporation. Utilities/ULB should also be required to prepare a financing plan for meeting recurring O&M expenses. State-level workshops could be organized to sensitize utility managers about water reuse covering technology options, new standards, policy incentives, implementation challenges, and best practices in procurement. Historically, infrastructure development in the water sector has been fully funded by the Government of India. Given the worsening water crises in many Indian cities, the moment has come for the government to engage efforts and resources in developing wastewater reuse to meet industrial water demand. It may be a tough road ahead for utilities and government to fast-track the necessary interventions, but the long-term benefits of reusing wastewater are substantial.

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