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Sustainable Development of Water Resources Based on Wastewater Reuse and Upgrading of Sewage Treatment Plants in Developing Countries: A Case Study of Jammu and Kashmir, India

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Abstract: Sustainable development of a country or area requires availability of different resources and their efficient application. Water resources are one of the most valuable resources of a country. The proper use of water resources depends on appropriate management. Water supply management is a multifaceted approach, and an important affecting factor on this approach is the use of potential resources. Effluent reuse is proposed as an efficient solution to improve the management of water resources, particularly in developing countries such as India, where there is a Problem of water scarcity. Water stress has become a perennial concern in most Indian cities. The main Objective of the present study is to investigate requirements of sustainable development of water resources, especially in the case of wastewater recycling and upgrading of wastewater collection and treatment facilities. However, reuse of wastewater has many advantages that are discussed in the present study. Policies related to wastewater reclamation are more important in the Jammu & Kashmir, due to technologic, fundamental, and cultural limitations. These policies can have a significant impact on wastewater reclamation and water resources management.
Keywords: Sustainable development; Water shortage; India; Wastewater reuse.

I. INTRODUCTION

World Commission on Environment and Development has described sustainable development as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Thus, sustainable development is a movement to progress toward different goals, without any economic or environmental damages to future generations. The process of development must be accomplished, so that economic growth would not lead to any losses in the environment and culture or other spiritual inheritance of India. In the past few decades in India, one of the most damaged resources during the development process is water resources. Water stress has become a perennial concern in most Indian cities. 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.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.2 India is expected to add approximately 404 million new urban dwellers between 2015 and 2050. This rapid urban growth will be linked with higher industrial output and greater energy demand. There is a domino effect here, with water demand from households, industries and power plants growing simultaneously 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. Besides the important role of water in human and animal life, agriculture, and industry, it has a kinetic and dynamic role, and is even a vital factor in physical and geological systems. It participates in the adjustment of morphological properties of the earth’s surface. It also has an impact on natural events such as earthquakes and tectonic movements. Furthermore, water-related changes can cause polar ice caps to move. Due to inattention to problems of water resources, 20% of world population does not have access to clean water. Furthermore, 50% of the world population does not have enough and sustainable water resources.

This inappropriate sanitation has caused a high rate of morbidity and mortality in children. According to the World Health Organization (WHO) report, there were 3.4 billion cases of water-related diseases in 1999, and more than half of these cases have happened in children. Furthermore, it is predicted that the world will face a shortage in water resources for agricultural and industrial purposes when the world population doubles. Most of these problems are due to population growth in the world, as humans have used water resources increasingly to satisfy their needs in the fields of agriculture, economy, and industry. In addition to a quality problem, human activities have polluted many water resources. This pollution has threatened water resources in terms of quality and eliminated the possibility to use them. Due to the unavoidable process of development, scientists concentrate on a new approach of multidimensional management or, in other words, sustainable development of water resources. In recent years, developed countries have done many activities in order to optimize water consumption, decrease water losses, and use potential resources. However, in developing counties such as India because of less financial support, protection of water resources has not been considered properly. The most highlighted issue in developing countries like India is drinking water supply. Wastewater treatment and reuse and optimization of wastewater collection systems have lower priorities. Wastewater application includes agricultural irrigation, landscape irrigation, industrial and environmental use, improvement of recreational and tourist spaces, non-potable use, groundwater recharging, and even potable purposes. Given the region such as India, level of development, and policies related to the management of wastewater reuse, this usage can be different for various parts of the world. For example, in the less-developed regions of India Such as Jammu and Kashmir, the main objectives are agricultural irrigation, and feeding water bodies and plains.

II. STATUS OF WASTEWATER RE-USE IN INDIA

Reuse of wastewater is not new to India. Chennai Petroleum Corporation Ltd (CPCL) built a wastewater reuse plant in 1991. However, the idea did not garner mainstream appeal for several reasons: There is no clear policy environment to encourage and support reuse projects. With low sewerage network coverage and insufficient Sewage Treatment Plant (STP) capacity, there hasn't been much Secondary Treated Water (STW) available for reuse. STW is being used for agriculture in many places. Redirecting STW for industrial reuse may face opposition from the public. Most cities apply a differential tariff for domestic and industrial water consumers, with the industrial tariff significantly higher than the domestic tariff. Revenue from industrial water supply, in such cases, is used to cross subsidize cost of supplying water to households. By switching to reclaimed water, utilities will have to forego some of this additional revenue Surplus freshwater availability in some smaller cities and towns has made utilities complacent and over dependent on freshwater sources. These conditions that held back the development of reuse of reclaimed water are fast changing. The Government of India has emphasized reuse of reclaimed water in many urban development schemes such as Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat Mission, Smart Cities Mission and the Namami Gange programme. Sewerage coverage and treatment capacity are consistently improving across urban India. The cost of wastewater reuse technologies is falling. As a result, reuse projects have been undertaken in some cities such as Nagpur, Surat and Visakhapatnam.

III. STATUS OF WASTEWATER GENERATION IN INDIA

During 2015, the estimated sewage generation in the country was 61754 MLD as against the developed sewage treatment capacity of 22963 MLD. Because of the hiatus in sewage treatment capacity, about 38791MLD of untreated sewage (62% of the total sewage) is discharged directly into nearby water bodies.

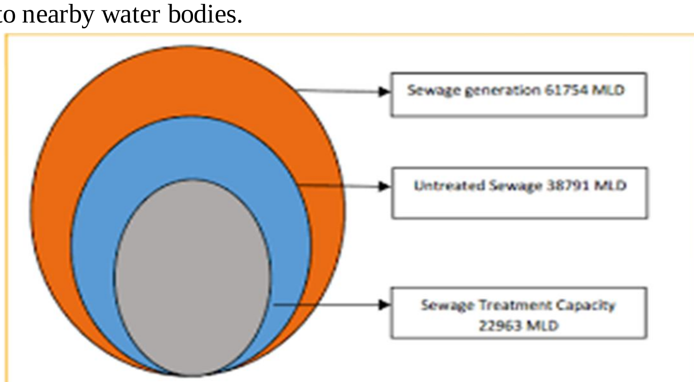

Fig 1: Showing Status of wastewater generation in India

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The five states viz Maharashtra, Tamil Nadu, Uttar Pradesh, Delhi & Gujarat account for approximately 50% of the total sewage generated in the country. Maharashtra alone accounts for 13% of the total sewage generation in the country. Maharashtra, Gujarat, Delhi, Uttar Pradesh & Gujarat account for 67% of the total sewage treatment capacity installed in the country. No sewage treatment plant has been established in seven states/UTs viz. Arunachal Pradesh, Chhattisgarh, Daman Diu, Nagaland, Assam & Tripura. The capacity of STPs installed in the two states viz. Himachal Pradesh & Sikkim is adequate to treat the total quality of sewage generated in these states.

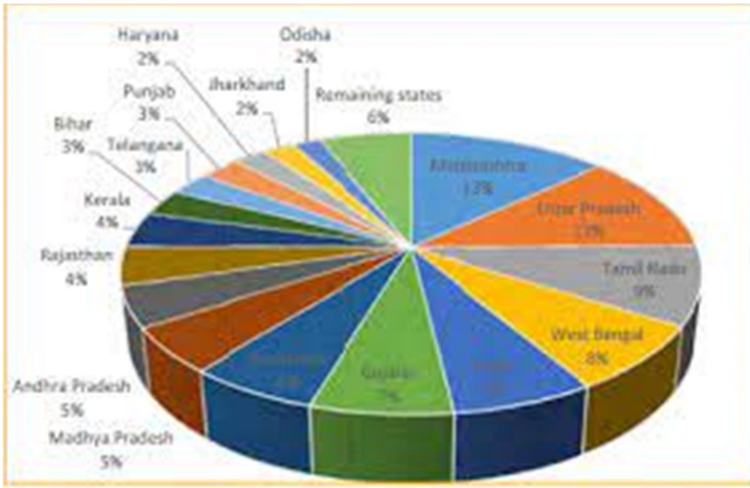

Figure 2: Showing status of sewage generated in different states of India

There are 35 metropolitan cities (more than 10 Lac Population)15,644 million Liters per Day (MLD) of sewage is generated from these metropolitan cities. The treatment capacity exists for 8040 MLD i.e., 51% is treatment capacity is created. Among the Metropolitan cities, Delhi has the maximum treatment capacity that is 2330 MLD (30% of the total treatment capacity of metropolitan cities). Discharge of untreated sewage in water courses both surface and ground waters are the most important water polluting source in India. Out of about 38000 million liter per day of sewage generated treatment capacity exists for only about 12000 million liter per day. Thus, there is a large gap between generation and treatment of wastewater in India. Even the treatment capacity existing is also not effectively utilized due to operation and maintenance problem. Operation and maintenance of existing plants and sewage pumping stations is not satisfactory, as nearly 39% plants are not conforming to the general standards prescribed under the Environmental (Protection) Rules for discharge into streams as per the CPCB's survey report. In a number of cities, the existing treatment capacity remains underutilized while a lot of sewage is discharged without treatment in the same city. Auxiliary power back-up facility is required at all the intermediate (IPS) & main pumping stations (MPS) of all the STPs.

IV. STATUS OF WASTEWATER GENERATION IN UNION TERRITORY OF JAMMU & KASHMIR

The wastewater generation is both generated by Industrial and municipal sources. Initially with development and Industrialization, wastewater from industries generation was significant and municipal wastewater was less. Over a period of time, with increased environmental activism, wastewater generation from industrial sector has been captured, treated and recycled, making it sustainable by its use for majority sector. Municipal sector sewage over a period of time has increased due to exponential degree of Urbanization and left an inseparable impact on urban perennial water sources such as surface riverine and ground water treatment.

Overall status of the UT:

1) *Total Population:* Urban Population & Rural Population separately

a) Urban Population = 48.43 lac

b) Rural Population = 101.57 lac

2) *Estimated Sewage Generation (MLD)*

a) Urban @ 108 lpcd = 523 MLD

b) Rural @ 44 lpcd= 447 MLD

3) *Details of Sewage Treatment Plant*

a) Existing no. of STPs and Treatment Capacity in (MLD): 15 Nos./139.40 MLD

b) Capacity Utilization of existing STPs: 82.90 MLD

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c) MLD of sewage being treated through Alternate technology: 0.52 MLD
d) Gap in Treatment Capacity in MLD: 383.08
e) No. of Operational STPs: 11 Nos.

As per details from Census 2011, Jammu and Kashmir has population of 1.25 Crores, an increase from figure of 1.01 Crore in 2001 census. Total population of Jammu and Kashmir as per 2011 census is 12,541,302 of which male and female are 6,640,662 and 5,900,640 respectively. Out of total population of Jammu and Kashmir, 27.38% people live in urban regions. Of the total population of Jammu and Kashmir State, around 72.62 percent live in the villages of rural areas. The decadal growth rate from 2001 till 2011 has shown a decadal growth rate of 23. 7%, but after 2011, there has been a decline in growth rate and average annual growth rate has been 2.10 for last 6 years. After 2012, the population has shown a decline rate and computation related to population growth starting 2012 has been recorded to arrive at average population growth rate of 2.02% per annum. At present, as per Central Pollution Control Board (CPCB) estimations, 85 liters per capita per day (LPCD) out of 135 LPCD of wastewater supplied to any household is released back in form of sewage from households. It is estimated that this may increase to 121 LPCD in year 2030, with increase population consuming water use and diminishing waste water recycling and reuse in municipal sector. Assuming above provided CPCB estimates, it can be concluded that out of total daily water supply, approximately 62% of total water supply or 187 MLD of water is generated as city sewage or urban sewage. With CPCB records, State poof J&K has a total water supply of 267.42 MLD to Class I cities, while Class II cities had a total water supply of 34.24 MLD in 2010. This makes a total of 301 MLD of water supplied to its citizens. But in J&K as per estimate made by J&K Urban Environmental Engineering dept. (UEED), 80% of total water supply, including leakages and NRW water is accounted for contributing to sewage generation. Hence sewage generation is high and same is used for computation of total sewage generation for entire Union Territory. For wastewater generation estimates, the sewage generation is estimated at 80% of total water supply per capita per day.

Table 1: Showing estimated wastewater generation

Year	Total population	Annual Growth Rate	Total Water supply for J&K State at Average Per capita Waste Water Supply @135 Liter per capita day	Total Wastewater /sewage Generation/day in J&K state@80% of total water supply or 108 Liter per capita day
		Percentage	MLD	MLD
2012	12,837,551	2.20	1733	1386.4
2013	13,125,956	2.15	1770	1416
2014	13,414,647	2.11	1807	1445
2015	13,703,350	2.06	1844	1475
2016	13,991,468	2.02	1881	1504

For future forecasting population growth in relation to water supply and related sewage generation, 2016 has been taken as a base rate and is used in following table:

Table2: Showing Forecast Population growth in relation with waste water generation

Year	Average Decadal Growth Rate	Total Water supply for J&K State in MLD at Average Per capita Waste Water Supply @135 Liter per capita day	Total Wastewater /sewage Generation/day in J&K in MLD @80% of total water supply or 108 Liter per capita day
2023	10.55	2079	1663
2031	21.1	2518	2014
2041	31.65	3315	2652

Against the, present, J&K total sewage treatment capacity, which includes present operational and proposed STP's is provided below:

Table 3: Showing total Sewage treatment plant capacity

S.NO	Parameter	Srinagar		Jammu	Anantnag
		JKLAWDA	UEED		
1	Total capacity of sewage treatment in present	16.1 MLD Brari Nambal. 7.5 MLD Hazratbal. 4.5 Lam Nishat MLD. 3.2 Habak MLD.	17.08MLD at Brari Numbal	27 MLD at Bhagwati Nagar (Completed but network not connected). 30MLD (Non-functional. 10 MLD (unfunctional)	4MLD at Mehndikadal.
2	Planned for 5 years (Scheme)	Z1=69MLD Z11=53MLD	164 KLD at Aloochi Bagh. 130KLD at Achan	164 KLD at Bhagwati Nagar 4KLD at Raipur Satwari,	5MLD MCDSTP and sewerage pipe line

So, with present condition of sewage treatment plant installation, J&K may face a shortfall of providing treatment to entire municipal and industrial wastewater.

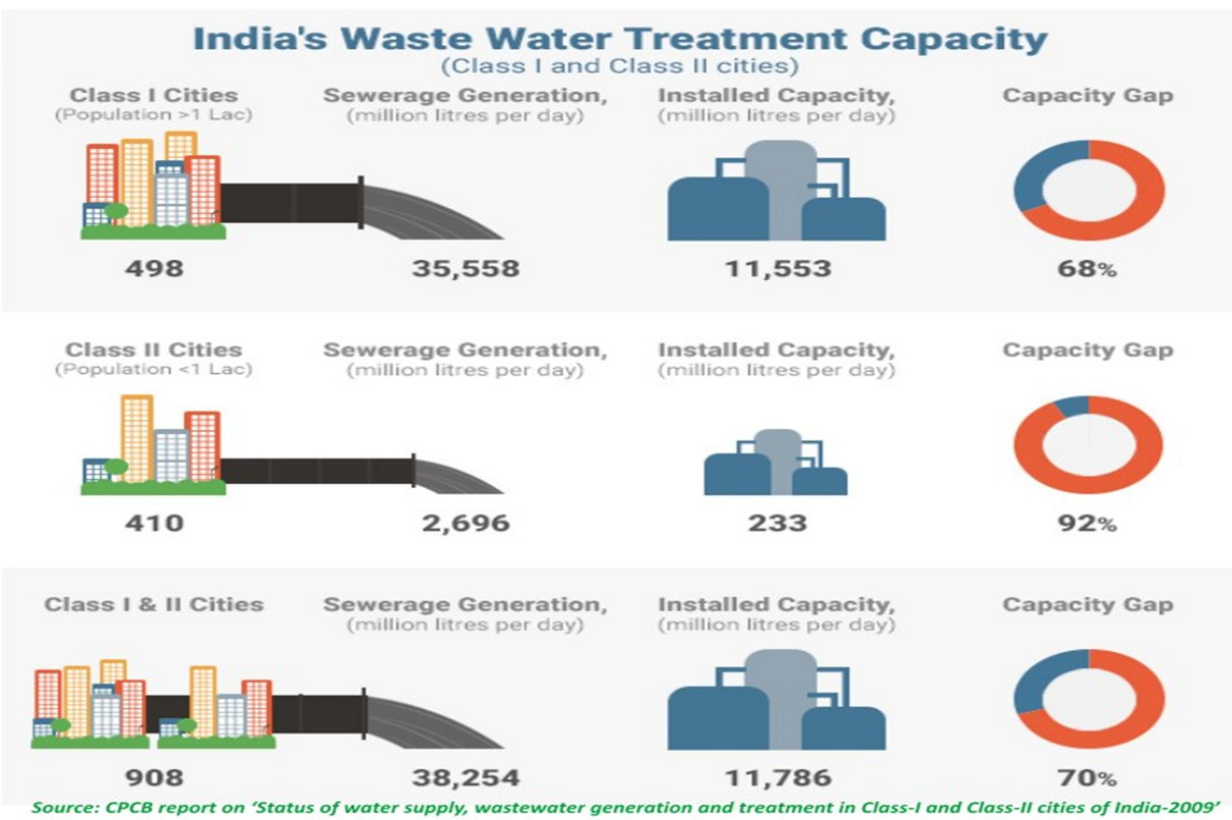

Figure 3: Showing wastewater generation and treatment

V. OPPORTUNITIES FOR USE OF WASTEWATER REUSE IN UT OF J&K

Water is a state subject and the provisioning of water and wastewater services to households is a responsibility entrusted to local governments. The regulatory environment for reuse of reclaimed water is influenced by many central, state and local government agencies, as shown in the following figure. The key policy notes that support wastewater reuse are as follows:

1) The Water (Prevention and Control of Pollution) Act of 1974 has given discharge norms for sewage and industrial effluents. Industries and local bodies are mandated to treat wastewater to the defined quality level before discharge.
2) The National Urban Sanitation Policy (NUSP), 2008, endorses reuse of reclaimed water, and recommends a minimum of 20% reuse of wastewater in every city. The National Water Policy (2012) recognizes reuse of reclaimed water as an important factor for meeting environmental objectives and suggests preferential tariff to incentivize reclaimed water over freshwater.
3) The J&K State Water Resources Management Act 2010 also vests responsibilities with state government to prepare the State Water Policy and Plan to ensure sustainable use of water resources through providing treatment and reuse of effluents and wastewater. Though wastewater reuse is endorsed in many policies and programmes, there is a lack of clear guidelines and frameworks to support the implementation of such projects. As a result, the reuse of reclaimed water for non-potable purposes continues to face challenges. The problem is further exacerbated by limited enforcement of the restriction to extract groundwater for non-potable purposes. More detailed policies and stronger enforcement is needed for wastewater reuse projects to be viable. In the last few years, the Government of India has taken many concrete steps to promote reuse of wastewater. It began with regulating industrial water consumption and enforcing mandatory water reuse targets for industries. Cities have set their own, more stringent targets. For example, Delhi has adopted aspirational reuse targets to treat and reuse 25% of total sewage produced by 2017, and increase the same to 50% by 2022, and to 80% by 2027. Against this background, municipalities across India have started to pursue reuse projects. Some of these utility-led reuse initiatives in the recent past are as follows:
4) Surat Municipal Corporation (SMC) built a 40 MLD reuse plant in 2014 to supply reclaimed water to Pandesara Industrial Estate.
5) Chennai Metro Water Supply and Sanitation Board (CMWSSB) awarded a PPP-based reuse project contract in 2016 to develop 45 MLD reuse capacity on the design, build, and operate (DBO) model to supply non-potable water to industries.
6) Bengaluru's water utility has built a 10 MLD tertiary treatment plant at Yellahanka that supplies reclaimed water to Bengaluru International airport.
7) Maharashtra Generation Company (MAHAGENCO) and Nagpur Municipal Corporation (NMC) have jointly invested in a reuse project where treated water from an STP is further treated and used as cooling water.

a) A review of these and other existing reuse projects reveals some common design features:
b) Most successful PPP-based reuse projects involve a single large consumer (end user).
c) The cost of treatment is bundled with cost of conveyance. Successful reuse projects, such as the Nagpur Tertiary Treatment Reverse Osmosis (TTRO) plant, and the Bamroli TTRO, needed significant capital subsidies to become viable. The initiation of these projects suggests that businesses are interested in this sector and that reuse projects can be viable if prepared and structured correctly and backed by supportive policies and institutions. Many other municipalities, however, have limited interest in reuse. This may be partly because they are not familiar with the innovative technologies and project structures involved and lack the resources to develop these projects on their own. The central government could boost the roll-out of water reuse by putting in place a national-level scheme. The first step would be to provide support for city-level scoping studies, leading to more detailed feasibility studies and assistance in contract preparation. A key purpose of the feasibility studies will be to establish the technology and market parameters of the project. Getting these parameters right will be critical to its success. The next section highlights some of the key considerations. The first step would be to provide support for city-level scoping studies, leading to more detailed feasibility studies and assistance in contract preparation.

   A key purpose of the feasibility studies will be to establish the technology and market parameters of the project. Getting these parameters right will be critical to its success. The next section highlights some of the key considerations.

VI. ENVIRONMENTAL BENEFITS OF WASTEWATER REUSE WITH URBAN PLANNING

Water recycling is a critical element for managing our water resources. Through water conservation and water recycling, we can meet environmental needs and still have sustainable development and a viable economy. Recycled water can satisfy most water demands, as long as it is adequately treated to ensure water quality appropriate for the use. Figure 1 shows types of treatment processes and suggested uses at each level of treatment.

In uses where there is a greater chance of human exposure to the water, more treatment is required. As for any water source that is not properly treated, health problems could arise from drinking or being exposed to recycled water if it contains disease- causing organisms or other contaminants.

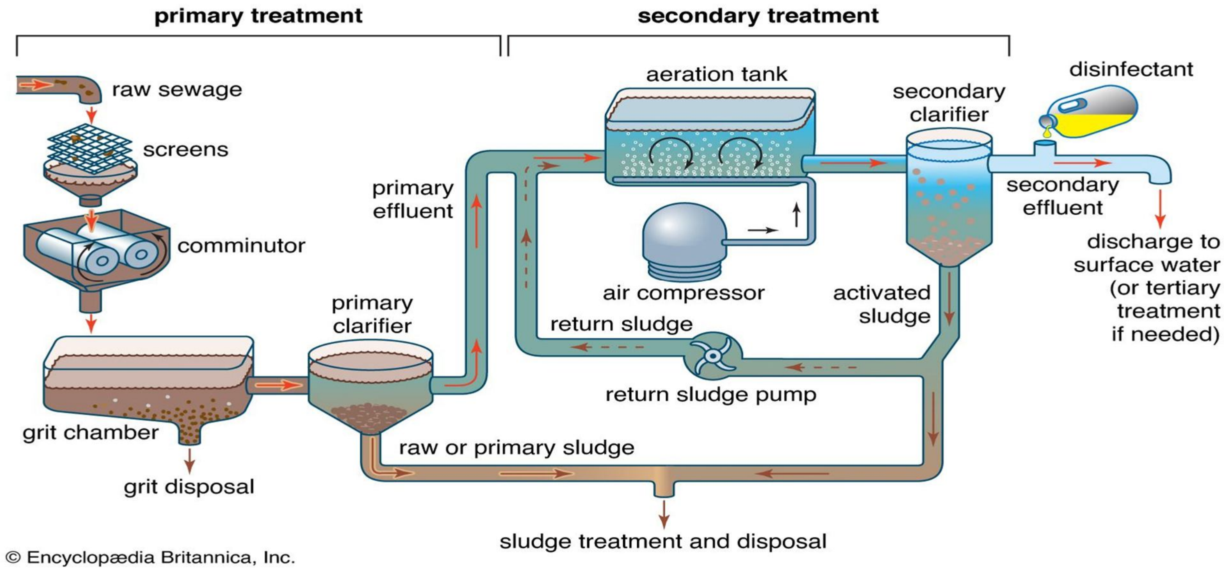

Figure 4: Showing primary and secondary treatment of sewage

Traditionally, water authorities have managed their water supply, sewerage and stormwater drainage systems as separate entities. Integrated urban water planning is a structured planning process to evaluate concurrently the opportunities to improve the management of water, sewerage and drainage services within an urban area in ways which are consistent with broader catchment and river management objectives. Catchment management impacts directly and indirectly on all three components of the urban water cycle, having effects on drinking water quality, wastewater treatment and stormwater management.

A simple framework of hazard identification, assessment and management under-pins the management of both catchments and urban water cycle elements. The New South Wales Department of Land and Water Conservation (DLWC, 2001) has developed an integrated urban water planning process through a number of recent pilot-studies conducted in partnership with local authorities in studies in the New South Wales towns of Finley, Goulburn and Bombala. The process links urban water management objectives to overall catchment and river management objectives. As a prelude to the integrated urban water planning process, DLWC undertakes an assessment of water quality and flow conditions, with particular focus on the sources of nutrients in catchment discharges. This data assists in shaping appropriate urban planning responses, particularly when urban discharges are a significant proportion of total nutrient discharges. The pilot studies have shown that an integrated approach to urban water, sewerage and stormwater planning can identify opportunities that are not apparent when separate strategies are developed for each service. The pilot studies have shown that both water conservation measures and water reuse are important contributors to environmental water quality improvements, and can also reduce water supply costs. The result is better-integrated, more sustainable solutions and substantial cost savings for local communities. Savings of up to 50% of capital costs have been identified in the pilot studies, but this may be exceptional. It is probably more practical to set a modest target of 15% to 20% savings and to see if this can be bettered. The conduct of an integrated urban water planning study is often a less costly process than traditional separate water and sewerage strategy studies. The integrated urban water planning produces a rapid screening and shortlisting of potential opportunities in partner-ship with the community. The process can lead to significant savings in project investigation and development costs, as well as the sorts of capital and operating costs savings which have been identified in the pilot studies.

VII. IMPLEMENTATION OF WASTEWATER RECYCLING PROJECTS IN UT OF J&K.

Public support is proving to be one of the most important, and potentially volatile, aspects of successful recycled water project implementation. As the public becomes more aware of the use and role of recycled water, more attention may be focused on applications, potential contact with humans or other plants or animals that humans come in contact with or ingest, and potential health concerns related to recycled water (particularly in non-industrial uses).

New pollutants are emerging, and will continue to emerge, as testing technologies improve, and potential health effects of the pollutants (or combinations of pollutants) are discovered. Current examples include endocrine disrupters, pharmaceuticals, and personal care products (PPCPs). Initially there will be limited scientific information related to these contaminants due to low pollutant concentration levels, detection limitations, statistical error, complexity of the pollutants, limitations in treatment technologies, and lack of long-term epidemiological data. Agencies, the public, and politicians will have to weigh relative risks against real and perceived costs, increasing water demands, and in many cases, diminishing quality and quantity of raw water supplies. Successful promotion and implementation of recycled water projects will require proactively addressing these concerns through education, research, advancements in water treatment technologies, O&M practices, and public outreach.

The points below expand on the broad ‘success’ criteria previously discussed. Not every project will be able to satisfy all these points, and many projects may not need to do so to be successful. Varying degrees of emphases will be required, depending on the recycled water use, and many other aspects of the project. The most successful projects will tend to have:

Public and political acceptance and support of the identified use(s), proposed or planned facilities, monitoring and safety protocols, long-term O&M procedures, and overall acceptance of the sponsoring agency and its ability to successfully build and operate the project.

1) Well-defined project purpose(s) and identified project driver(s), including (but not limited to) offsetting of potable water use, reducing pollutant loads and discharge volumes in receiving waters, and reducing treatment volumes in possible downstream treatment facilities.
2) Regulatory and project sponsor support of the project at all levels including the ability of the sponsoring agency to successfully build and operate the project.
3) Full assessment (to the extent possible) of health and safety implications of recycled water being used for its identified purpose(s).
4) Ability, through diversions, storage, expansion of existing facilities, or construction of new facilities, to supply each user’s demand when and as it is needed.
5) Full assessment of environmental advantages and disadvantages of the project, including handling of treatment facility waste streams.
6) Full consideration of how the project fits into other possible integrated planning efforts.
7) Construction or acquisition of adequate conveyance facilities to deliver recycled water to the location of use.
8) Full assessment of the cost of the project(s), incorporating anticipated future supply restrictions, waste stream management, and anticipated adjustments, if any, to costs and available funding sources.
9) Full assessment of alternatives, with strong public involvement.
10) Attainment of adequate funding for any required acquisition and construction, and arrangement for long-term O&M funding for project infrastructure and facilities.
11) Long-term project performance and water quality that meets or exceeds commitments and expectations.

VIII. CONCLUSION

One of the most useful factors in the sustainable development of water resources, especially in areas such as the Jammu & Kashmir, is wastewater reuse or, in other words, wastewater reclamation. Wastewater recovery in J&K is limited and faces various problems. One of the issues affecting development in reuse of wastewater is mismanagement and lack of appropriate management approaches. If policy makers change their approach to wastewater from a discarded material to a valuable commodity, substantial developments will occur within this area. Due to lack of proper operation of well-designed wastewater treatment plants, training operators and also improving and promoting wastewater treatment processes can be an effective step to improve the situation of wastewater reuse. The authors recommend that future studies be conducted about upgrading wastewater treatment systems with appropriate cost-effective processes, performance evaluation of standards, and designation of standards based on the climatic conditions of the region, the culture, and social status.

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