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Review Article

Potential for Applicability of Decentralized Approaches in Sewage Treatment Systems in Indian Scenario

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ABSTRACT

The conventional sewage treatment systems have always been considered as a successful approach in treating sewage. However, the constraints and complications regarding the centralized approaches are progressively surfacing. Factors like improper design of the plants, poor maintenance, lack of reliable electricity supply and skilled labour has led to the non-functioning of most of the plants in the country. The present scenario of sewage treatment systems in India require a total paradigm shift from centralized to decentralized approaches where the sewage could be treated in the source itself. Thus, it is required to have an alternate approach from a disposal based linear system to a recovery based closed system. The decentralized approaches for treating sewage allows flexibility in management and possess greater benefits in terms of technical, economic, environmental and social aspects. Apart from the centralized systems, the decentralized sewage treatment systems are more reliable, cost–effective and have better efficiency in treating sewage without leaving any sludge for disposal. The potential advantages of decentralized systems signify that it is a method that deserves greater applications and attention by every section of society from policy makers to every interested members of the public.

Keywords: Sewage; Centralized system; Decentralized systems; Efficiency; Wastewater

INTRODUCTION

Water as a universal solvent has the property of incorporating various impurities and transporting the mixed waste solutions to various places. Various conservative, non-conservative, persistent and accumulative substances continue to prevail in water that further becomes the indicators for pollution like coliforms, nutrients, DO, BOD and COD [1]. The quality of water is the consequence of natural phenomena like run-off, infiltration and the acts of human beings through the discharge of domestic or industrial wastes [2]. Waste water is a commonly used term to explain the by-product of domestic, industrial, commercial or agricultural activities along with any surface runoff or storm-water, and any sewer inflow or sewer infiltration containing organic and inorganic matter in suspended, colloidal and dissolved forms [1].

In order to decontaminate, the wastewater is further treated to improve and purify the water for reusing or releasing it into the environment either in rivers or ocean and finally to land [2,3]. The absence of proper wastewater treatment facilities, maintenance and the outdated systems compromise with the treatment efforts and thus results in treating only 20% of the wastewater produced globally [4]. Mostly in the countries having high income rate the treatment capacity is higher that is 70% which further declines down to only 8% in the lower income countries [5]. Sewage is the subset of wastewater which is used to describe all types of waste generated from domestic dwelling including pollutants like fecal matters, urine, soaps, detergents, food particles, rags, papers and other things that are disposed in a drain [6].

In India, the outflow of untreated sewage and the gap between the generation and treatment of domestic wastewater is the vital source of pollution of both surface as well as ground water. Recent studies have revealed that 50-80% of untreated sewage is disposed in the water bodies [7]. This is not only because India lacks treatment capacity but also that the sewage treatment plants that exists do not operate and are not maintained [8]. According to the reports of CPCB, the centrally owned sewage treatment plants remain non-functional most of the time primarily due to improper design or poor maintenance of the plants or lack of reliable electricity supply together with absentee employees and poor management for the proper functioning of the plant itself. This causes the uncollected

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waste to accumulate in the premises causing unhygienic conditions and releasing of pollutants that leach into surface and groundwater.

The continuous and expanding inefficiency of the Centralized Sewage treatment plants has now shifted the focus towards the Decentralized systems which poses a greater benefit for the society both in terms of economic and environmental aspects. The decentralized systems are the on-site local treatment systems installed to treat the sewage or wastewater at the point source without causing any further pollution.

SEWAGE TREATMENT SCENARIO IN INDIA

Urbanization is an inevitable global phenomenon having its own pros and cons. On one hand, it is a progressive transformation from traditional rural economies to contemporary industrial one. But on the contrary, it also gives rise to various environmental problems like water supply, wastewater generation and its unscientific handling. The sewage alone accounts for 75% of the surface water contamination in India [9]. The untreated sewage either percolates into the ground and thus contaminating it or is directly discharged into the natural drainage system joining the rivers or lakes or on lands used for agriculture or into sea [9]. The effect of incorporating the sewage and surface water like rivers and oceans can be catastrophic. According to WWAP, 70% of the industrial wastes in the developing counties are directly dumped into waters where they pollute the usable water supply. These untreated and harmful sewage effluents when fall into rivers become the originator of several diseases and misbalances in the ecosystem leaving marked effects on organisms [3]. Sewage when drained in large quantities into the rivers coagulates the water by reducing the dilution of the constituents. Thus, the water becomes stagnant which further give rise to various water borne diseases. It can further lead to Eutrophication which increases the BOD level thus affecting the aquatic life [10].

The BOD level is considered to be the primary pollutant contributed by both domestic and industrial wastewater and is required for assessing the quality or the pollution level in any surface water [11]. Overall BOD load discharged into the surface water bodies by the Indian states has been assessed as 14352.7 TPD out of which less than 1% is contributed by industries [8].

The CPCB status of 2014-15 on the status of the sewage treatment plants in India, it was found that out of a total 816 municipal (centralized) sewage treatment plants all over the country, 522 were operational having a total capacity treatment of 18883.2 MLD, 79 were not operational, 145 were under construction and 70 new STPs were proposed to build. These 816 STPs has a total capacity of treating only 23277.6 MLD of total sewage generated that is only 38% of the total sewage load. This creates a huge gap between the quantity of sewage generated and the capacity of its treatment thus leading to approximately 70% of the sewage getting directly disposed into the surface waters. The highest sewage generating states are Maharashtra, Tamil Nadu, Uttar Pradesh, Delhi and Gujarat accounting for 50% of the total sewage generated in the country out of which Maharashtra alone generates 13% of the sewage in the country [8]. Considering the generation these states have 67% of the total sewage treatment capacity installed in the country. Although no treatment plants are set up in Arunachal Pradesh, Chhattisgarh, Daman Diu, Nagaland, Assam & Tripura.

The direct discharge of the untreated sewage into the surface as well as ground water accounts for the major water pollution factor in India. The treatment capacity of the existing plants is not effectively handled having inadequacy in the operation and maintenance. 39% of the existing treatment plants do not comply with the general standards prescribed under the Environmental (Protection) Rules for discharge into streams. In many cases, the treatment capacity remains underutilized while discharge large quantity of sewage in to the rivers without treatment.

According to the CPCB report- Status of Sewage Treatment in India, shows that all cities generates a total sewage of 15,644 MLD but has the treatment capacity of only 8040 MLD. The total sewage treatment capacity gap between the sewage generation and its treatment in Class I and Class II cities of India combined is also as high as 70%.

According to the current status of CPCB, 70% of the untreated sewage is directly dumped into the rivers. If taken Ganga, for which the first pollution abatement program was started by the Government, domestic sewage accounts for 85% of the river's pollution load which is generated from 50 cities located along the river bank [12]. The 36 Class I cities along the banks of Ganga where 99% of the sewage treatment plants are installed generates 96% of the total sewage flowing into the river [7]. The overall sewage generation along the stretch of Ganga is 2723.30 MLD out of which only 1208.80 MLD is treated. Even the past status shows that the investments in alleviating the sewage treatment capacity, the gap between the treated and untreated still remains the same. The major focus has been shifted from cleaning the river to installing more sewage treatment plants. But the actual solution lies in managing the sewage differently by the cities.

DESIGN OF CENTRALIZED SEWAGE TREATMENT SYSTEM

The centralized sewage treatment systems mainly focus on the municipal treatment plants applied to a much larger scale. These centralized systems are publicly owned and are used for treating the sewage for the entire community (Figure 1).

Stages in the sewage treatment plant process: -

Stage 1: Preliminary Treatment: This is the stage where the coarse solid particles and the other bigger sized particles are separated out before damaging or clogging the pumps and the sewage lines. This treatment stage includes large filtering screens or grit removal. The influent passes through a bar screen, a mechanical filter to remove large and heavy objects. This is done either automatically or manually depending on the scale of the treatment plant. The solids are collected afterwards and are disposed in a landfill or incinerated.

Stage 2: Primary Treatment: -In this stage, the sewage is kept in an inactive state in order to separate out the oil and grease from the sewage. As the sewage rests in a uninterrupted basin, the heavy solids settles to the bottom while the oil, grease and other lighter objects float to the surface. Thus, the purpose of this stage is to separate the organic and inorganic heavy solids. The sediments are removed and remaining contaminated liquid is passed for further treatment.

Stage 3: Secondary Treatment: -The effluent from the primary treatment stage is treated here to remove the dissolved and suspended biological matter. This stage may also require an additional separation process for eliminating the micro-organisms. This stage alone removes more than 90% of the suspended solids

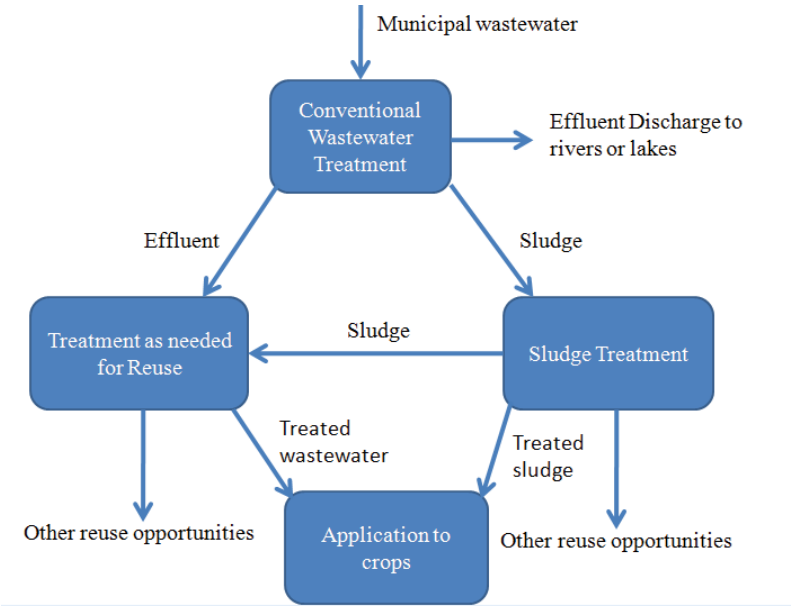

Figure 1: Fate of wastewater [11].

Figure 2: Process of sewage treatment in a STP [12].

from the total sewage effluent treated.

Stage 4: Tertiary Treatment: -This stage helps to disinfect the treated water for allowing flowing out into the fragile environment. The treated water is disinfected either chemically or physically before discharging into the surface water streams. Other than discharge, this water can be used for irrigating golf course, green way or any park (Figure 2).

The collection, treatment and disposal are the three major components of any waste water treatment management system. Out of this in the centralized sewage treatment systems, 80% of the total investment accounts for the collection only [13]. This contains a common and centralized sewer system for collecting all the sewage from households and other commercial and industrial places. This is considered to be an off-site management system as the location of the treatment plant and the disposal of the treated residue is often far off from the point of origin [14].

HISTORY OF CENTRALIZED SEWAGE TREATMENT SYSTEM

The idea behind the concept of the centralized form of sewage collection and treatment was developed in the middle of nineteenth century among the highly urbanized and industrialized sectors of Central Europe and USA. The massive outbreak of catastrophic diseases like cholera and typhoid due to open disposal of household wastes led to the technical solution of forming a public sewer system of collecting all wastewater and transporting it for treatment outside the locality. Thus, the first inclusive sewer network was built in Hamburg around 1842 followed by other cities as well. However, the treated wastewater was directly disposed into the surface water thus making it vulnerable for contamination and weakening the self-purification property. Later many advanced technologies were developed which were considered to be suitable for large cities on a large scale [15]

As in the developed countries this conventional method was highly preferred and considered to be the standard tool of environmental protection and control and so was extended to the developing countries as well. Therefore, the centralized management system was applied to various large cities and secondary towns in the industrialized as well as in middle or lower income countries [16] (Table 1).

Decentralized Sewage Treatment System: Centralized systems approach towards the sewage collection and treatment has generally failed in meeting the needs of the communities and their limitations are progressively surfacing. Developing countries lack funding and technical expertise for the centralized facilities to operate and manage. This creates a new opportunity for the implementation of the decentralized waste water management. Confined local budgets, lack of local expertise and funding results in the poor operation of the wastewater treatment plants. In this context, wastewater could be considered as a source of energy from which portable or non-portable water and energy along with fertilizers could be derived. The centralized sewage treatment systems are costly to build and operate and involve advanced collection and treatment process for the collection, treatment and discharge of large quantities of wastes. These systems are ideal model for the developed countries but for the developing nations however, just the reverse is required as in the latter the domestic, business and industrial wastewaters are either not treated or partially treated on-site and is directly discharged into the nearby ground, drain or any nearby watercourses.

Currently, the sewage treatment management is in the dilemma of profusion of irregularities that requires a paradigm shift from the current centralized to decentralized management of sewage. Certainly, in the present context, the decentralized system can

Table 1: Pros and cons of Centralized Sewage Treatment Systems [2].

	Pros	Cons
Technical Aspect	High Treatment efficiency of conventional treatment systems.	High energy consumption; Massive pumping required; large solution but less flexibility.
Economical Aspect		High constructional and operational cost involved; Large investment required; labour required
Social Aspect	Located far away from the human settlements	Remote areas are the last to be connected;
Institutional Aspect	Small number of treatment plants easier to manage; management conducted by organizations with high capacity	Most of the time not effectively and efficiently monitored.

fulfill all the requirements of the conventional centralized system and can also reduce the potential residual effluent contamination and emerging micro-pollutant [17].

This decentralized sewage treatment system is a theory of on-site management of sewage. The collection network is small, receiving lesser quantity of sewage that can be easily managed with simple and natural treatment methods [18]. Thus, the system will allow for more independent, self-maintained and sustained facilities ensuring the restoration of the wastewater resources. The decentralized sewage treatment systems can be of different scales like for every individual household, for a cluster of homes, in a neighborhood, in public facilities, in any commercial area or industrial parks and even for small portions of large communities [16].

Centralized or decentralized Wastewater Systems: The major chauffer for the centralized water treatment comprises of centralized municipal governance, economies of scales, knowledge of water treatment methods and limited availability for remote monitoring and control which has restrained the reclamation and usage of wastewater. For maximizing the use, water transfer and distribution pipelines have to be constructed at a price cheaper than the tap or fresh water. According to the World Bank, "The implementation of low cost sewage treatment will be the greatest challenge in the water and sanitation sector for the upcoming two decades that will permit selective reuse of treated effluents both in agriculture as well as in industrial purposes" [11].

The developing countries usually lack funding to construct and get the technical expertise to manage and operate the centralized system [19]. According to the Environmental Protection Agency in the United States, decentralized wastewater systems can prove to be the best alternative for the centralized systems by providing more cost-effective and long-term options for meeting the public water quality goals. On centralization, some general statements maybe provided from a series of authors such as that:

- Although the wastewater collection system already exists but requires periodic maintenance for every 50-60 years [20].
- The cost of treating per unit volume is competitive to the decentralized systems and 80-90% of the capital costs are related to the collection systems in the densely populated areas [20].
- More expensive methods are required for treating the diluted wastewaters [20,21].
- Overflow may happen by heavy rainfall events or contamination by industrial wastewaters [21].
- Reliance on electric energy supply will increase which may not be suitable due to economic or political crisis [16].
- Also, in order to clean the sewage system huge volume of portable water will be needed [16,20].

On decentralization, other general statements may be highlighted from various authors such as that:

- Decentralized systems can provide technologies to highly customizable products or processes [22].
- The recovery and reuse of treated water can be maximized [2].
- Applicable to various levels from individual to community [3].
- The possibility of domestic wastewater contamination can be excluded by industrial wastewater as well as the relative sludge produced [16].

Comparative Analysis: -

- **Sewage collection & transfer pipelines:** This refers to the pipelines setup for the collection and transportation of sewage from source to the treatment plant. These pipelines are made up of cement, cast iron, polyethylene placed deep under the ground. In the centralized system, the pump stations are situated based on the topography and the length of the pipelines thus increasing the cost of implementation and transportation of the sewage to the pumping station. Whereas in the decentralized system, common tanks are placed related to different buildings. Therefore, the price for collection and transportation is eliminated to some extent.
- **Land Requirement:** Factors like the cost of land, types of nearby areas to the treatment plants, safety and protection are considered for selecting the location of the treatment plant. Since the centralized system is an off-site treatment, thus the location of the plant requires a separate far-off place and the cost related to the construction of the huge plant along with its maintenance and protection and the cost of land are also accompanied. While in the decentralized system the treatment tanks are generally buried thus no space is occupied on the land.
- **Operation, maintenance and repair of STPs:** In the centralized system, usually the O&M cost is high due to the involvement of heavy mechanics, skilled operators and technicians. The condition is however reversed in the case of decentralized systems because of the ease of use and less use of mechanical and electrical appliances (Table 2) [23-25].

CONCLUSION

Considering the centralized and decentralized one, the Decentralized STPs have the advantages of working efficiently in low cost associated. Any kind of centralized treatment plant will usually consist of large area of treatment units which requires huge

Table 2: Comparison between centralized and decentralized sewage treatment systems.

Parameters	Centralized system	Decentralized system
Collecting system	Large Diameters; long distance	Small diameters; short distance
Area required	Installed in large area having enormous units Needs area far from population	Require less area as a single unit. Can be installed within a society.
Total capacity	Usually built for large capacity	Built for less capacity
Electricity consumption	More electricity needed	Less electricity consumed
Operation and maintenance cost	More cost associated; full time technical support required	Low cost associated; less demanding and can be monitored from remote
Uniformity of water	Different types of water	Uniform water
Dilution grade	More dilution	More concentrated
Risk	Risk on large scale	Risk distributed
Water transfer	Increase the needs for water transfer	Water is used and reused in the same area
No. of operators	More and skilled labour required	Less and un-skilled labour can also operate the plant
Social Control	Social cost is lost	More social control
Ease of expansion	High cost; more complex	Low cost; less complexity
Potential to reuse	Majority are linked with the river systems	In irrigation and horticulture
Sludge generation	Huge amount of sludge	Limited or no sludge generated
Sludge disposal	Critical	No sludge generation
Working efficiency	Weakens with time	Get enhanced with time

amount of money sanctioned by the Government. But on the positive part, the treatment efficiency the decentralized treatment systems increase with time which is not usual in case of centralized. Although having comparatively smaller size and capacity of the decentralized systems, they are still more flexible and can be applicable anywhere irrespective of the scale. In India, major quantity of sewage remains partially treated or untreated because the centralized sewage treating plants do not operate due to lack of electricity, less skilled labors and poor management. All these disadvantages can be easily over-come through the decentralized system as it does not require the above-mentioned factors.

Usually the centralized sewage treatment plants try to cope up with the effluent standards set by the Government. But the actual scenario is far behind that. The treatment efficiency of centralized sewage treatment plants lag behind in every aspect like COD, BOD and TSS. Whereas in Decentralized sewage treatment system, the sewage gets treated in the source itself which reduces the overloading of waste at a particular place. Also, the effluent water is used directly for various purposes like irrigation, horticulture and other reclamation applications whereas the effluent from the centralized sewage treatment either gets directly discharged into the river streams or is not according to the standards for any further uses.

Commonly the centralized sewage treatment plants are connected with other municipal plants for reclamation process which makes the investment and expenditure higher and more complex to investigate in comparison to any decentralized sewage treatment plant. Usually Government sanctions large funds for the construction of treatment plant on a large scale. The decentralized treatment plants can be installed at a much cheaper rate using environment friendly techniques which will allow better treatment of the sewage along with least harmful residue left. Although covering a vast area with larger capacity of sewage treatment, the centralized systems are not cost effective and inefficient in the treatment process. Also, the requirement of skilled labour and advanced and heavy machineries makes the CSTPs a bigger challenge in the upcoming years. This disadvantage can be easily overcome by using decentralized techniques which although being less in capacity possess higher and better working efficiency for treatment. Many rural and slum areas have poor connectivity with the sewer lines and treatment plant which possess a greater challenge for proper treatment. The decentralized approaches can fulfill the requirements of the conventional centralized systems and can also reduce the potential residual effluent contamination. The onsite treatment can provide a feasible solution for the sewage treatment that can comply with the environmental standards having better treating efficiency. Low cost with environment friendly technology makes the decentralized approaches suitable for longer run. It encourages the reuse of treated sewage for irrigation, gardening and other purposes. Thus, the system will allow for more independent, self-maintained and sustained facilities ensuring the restoration of the wastewater resources.

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