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Decentralized Wastewater Management System with 3R's Theory

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ABSTRACT: The world is facing a global water quality crisis due to haphazard urbanization and rapid industrialization. Consequently, there is a continuous pressure water resources and increasing the unregulated/ illegal discharge of contaminated waste water within the urban area. The occurrence of this phenomenon has created a threat to human health and wellbeing at the global level, with both immediate and long-term harmful consequences to the sustainable development of urban areas. A healthier future needs urgent global action for smart, sustained investment to improve wastewater management where investments integrated planning can sustainably Innovation to reduce the volume and contamination of wastewater produced, how to treat or even reuse the waste, and how to do it in an affordable sustainable way. It explains how generation and treatment cycle of waste water can be better understood and managed for better investment and management of major environmental, social and health conditions. Wastewater Management Systems encompasses a broad range of efforts that promote effective and responsible water use, treatment, and disposal and encourage the protection and restoration of the watersheds. In Indian cities, commonly we have centralized wastewater management system which conventional gravity sewers, one treatment facility, effluent discharge directly to surface water. Decentralized wastewater management technologies differ from conventional centralized systems in as they "Treat and Reuse or Dispose of wastewater at or near its source of Generation". The decentralized systems can be applied on different scales like individual households, a cluster of homes, a neighborhood, public facilities, commercial area, industrial parks, small portions of large communities with 3R's theory implementation.

Key Words: Waste Water Management System, Decentralization, 3R's (Reduce-Reuse-Recycle).

I. INTRODUCTION

The world is facing a global water quality crisis due to haphazard urbanization and rapid industrialization. Consequently, there is a continuous pressure water resources and increasing the unregulated/ illegal discharge of contaminated waste water within the urban area. The occurrence of this phenomenon has created a threat to human health and wellbeing at the global level, with both immediate and long-term harmful consequences to the sustainable development of urban areas. A healthier future required action for smart, sustainable improvement in wastewater management with integrated planning which should be sustainable innovative to reduce the volume of contaminatedof waste water generated, how to treat or reuse the waste water, and how to do it in an affordable sustainable way.

It explains how generation and treatment cycle of waste water can be better understood and managed for better investment and management of major environmental, social and health conditions. Wastewater Management Systems "Encompasses a broad range of efforts that promote effective and responsible water use, treatment, and disposal and encourage the protection and restoration of the watersheds". In Indian cities, commonly we have centralized wastewater management system which conventional gravity sewers, one treatment facility, effluent discharge directly to surface water.

II. WASTE WATER MANAGEMENT IN INDIA

India has 2.45% of land area and 4% of water of the world but has 16% of the world population. Total serviceable water resources in the country about 1123 BCM (690 BCM from the surface and 433 BCM from ground), which is just 28% of the water derived from precipitation.

The Urban Management Programme launched by NITI (National Institution for Transforming India) Aayog Report April, 2016 focuses on Integrated Urban Water Cycle Management for Sustainable and Resilient Water Infrastructure and Healthy Cities like Sustainable Waste Water Management (Decentralized) system with Recycle and Reuse of treated wastewater for effectively treating, recycling and reusing waste water at thermal power stations, Industries and other purpose as waste disposal standards of Central Pollution Control Board (CPCB).

III. STUDY AREA ANALYSIS

Jaipur is having been built in 1727 and is one of the best-planned cities in the country. It is the capital city of the state of Rajasthan and is a major business hub. Jaipur sprawls over 1700 so kilometers of which a little less than half is inside its Walled City. It is estimated to attain a population 34.95 lakhs by the year 2011 with 5.3% annual growth rate.

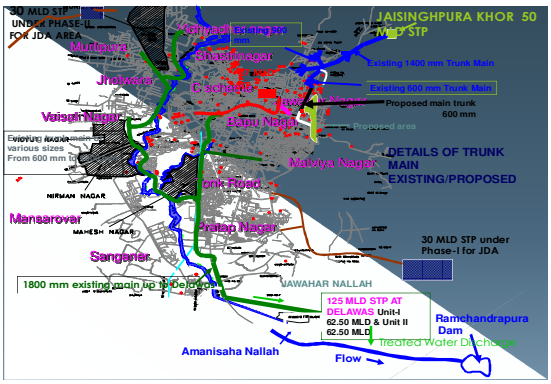


Fig: Existing land use pattern in Vidhyadhar Nagar-Jaipur
Source: Jaipur Development Authority (JDA)-Jaipur

IV. VIDHYADHAR NAGAR

Vidhyadhar Nagar is planned colony place in Jaipur city. It is located towards the north of the city, separated from the mainland by Amanishah Nala that runs throughout the length of Jaipur from north to south. It is located towards the north of the city and about 10 km far from the center of the city and is located on Vidhyadhar mark. It was designed by B.V. Doshi in 1986.

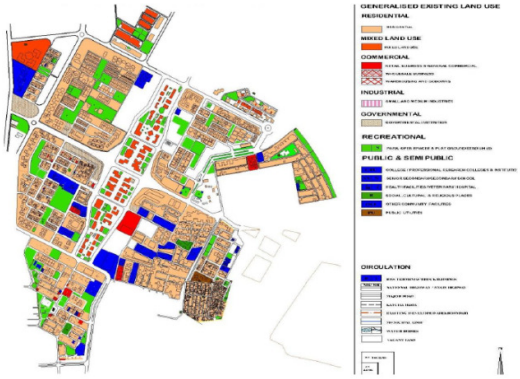


Fig: Existing land use pattern in Vidhyadhar Nagar-Jaipur
Source: Jaipur Development Authority (JDA)-Jaipur

The area of Vidhyadhar Nagar is 360 hectare with a population of about 1 lakh approx. The density is 360pph. There are in total 10 sectors in Vidhyadhar Nagar. One can reach the destination that is Vidhyadhar Nagar by boarding a bus at Shastri Nagar. Dahar Ka Balaji Railway Station is the nearest railway station which is about 4 km far from the place of Vidhyadhar Nagar. The place is about 16 km away from the Jaipur Airport.

Water supply:

- The city has an satisfactory water supply service and network by providing 126.5 lpcd water suplly and covering more than 86.5% population.
- However, on account of a high UFW (unaccounted for water) of 44%, the net water supply gets reduced to 82 lpcd. Here main resource of water is ground water, which is fast depleting (at the rate of 3m/annum) as a result of growing population pressure.

Sewerage: The city has a sewerage network covering only 80% of area. The maximum population resorts to septic tanks. In the absence of proper facilities in slums, the slum population resorts to open defecation, which is environmentally hazardous.

(As referenced in City Development Plan of Jaipur)

Other issues: • High operation and maintenance cost;

• Highly subsidized water supply;

• Depleting ground water with a steep drop in water table;

• Deteriorating water quality for both surface and ground water

- ❑ Sewerage of Vidhyadhar Nagar going to Delawas STP which is 35km far this area. So collection network is very costly.
- ❑ About 20% of leakage losses is there which have lots of issues.
- ❑ Treated water from Delawas STP about 125MLD is disposing of in Amanishah Nala means no any reuse of waste water.
- ❑ Waste Water is collected by Combine pipe system which is included grey & black both type of water at rainy season drainage also.
- ❑ Sewerage collection efficiency is low i.e. 77% of total sewage generated. The city is not fully connected with sewerage system.
- ❑ Insufficient capacity of wastewater treatment plants.
- ❑ The treated sewage is disposed into the Amanishah Nallah, means it is not reused in the city.
- ❑ In some areas, untreated sewage flows into drains, nallas and even on the roads.

V. SUITABLE WASTE WATER MANAGEMENT SYSTEM FOR STUDY AREA

For a small area like Vidhyadhar Nagar, Decentralized treatment should be introduced which can provide the safety and reliability in comparison to existing conventional large-scale treatment and can also offer many additional benefits to communities.

Decentralized wastewater management technologies differ and better from conventional centralized systems in that they "Treat and Reuse or Dispose of wastewater at or near its source of Generation".

The decentralized systems can be applied on different scales like individual households, cluster of homes, a neighborhood, public facilities, commercial area, industrial parks, small portions of large communities with 3R's (Reduce-Reuse-Recycle) theory implementation

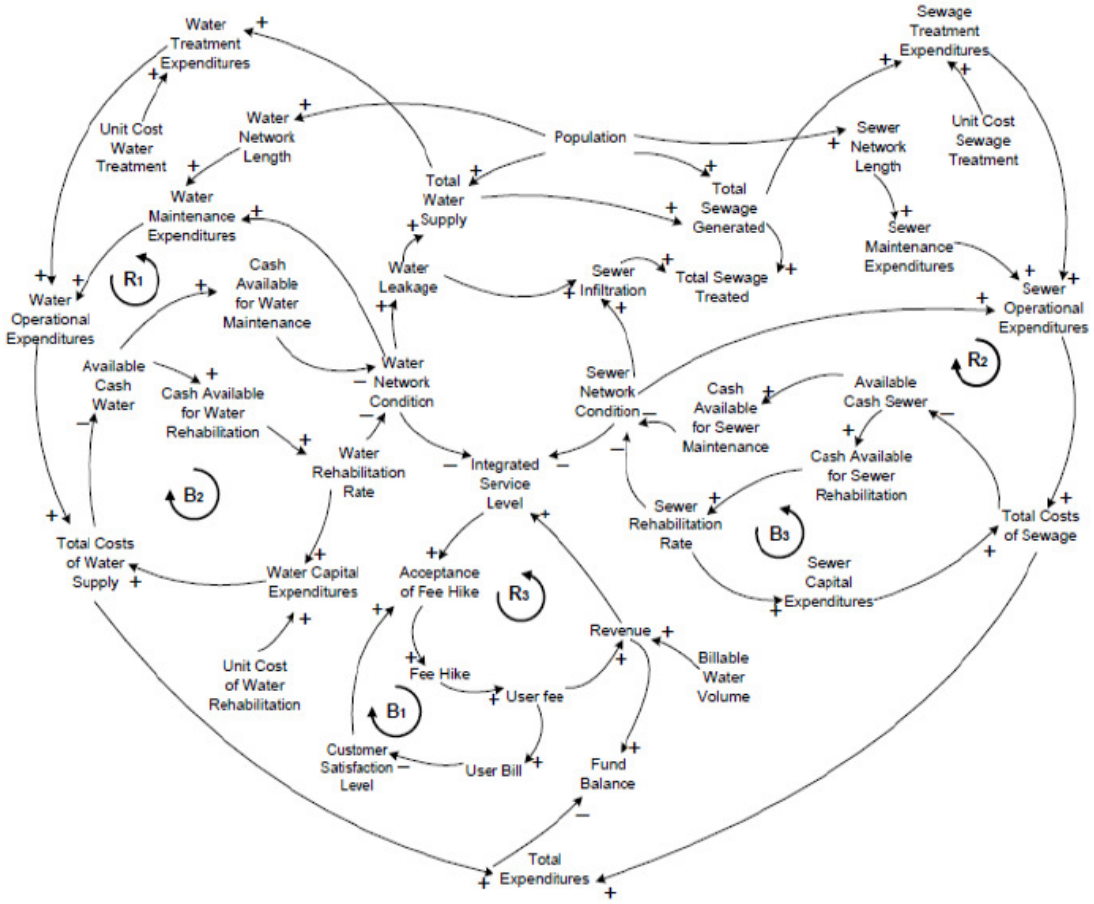


Fig. 1. Causal Loop Diagram For Urban Waste Water.

Source: McKenzie-Ray's Report on Urban Water India Final version

Decentralized wastewater treatment will be a sensible solution for communities because decentralized systems should be well operated system, well designed, proper maintained and to provide optimum benefits: Better for the environment, economy and for betterment of the people. Waste water recycling, Industrial waste water Reusing and recycling industrial water can reduce the pressure on water resources. Water Is Sometimes Recycled and Reused Onsite-For example when an industrial facility recycles water used for cooling processes. Another type of Recycled Water Is "Grey Water" which is reusable water generated from domestic, commercial and industrial area's units like bathroom sinks, bath tub shower drains, and clothes washing equipment drains. Grey water is reused onsite, typically for landscape irrigation. Use of nontoxic and low-sodium (no added sodium or substances that**.** National Science Foundation (NSF) International has worked on a wastewater treatment task group onsite residential and commercial Greywater treatment systems for many communities, decentralized treatment are:

- **Cost-effective and economical**
- Using energy and land wisely
- Responding to growth while preserving green space
- **Safe for protection of the environment, public health and water quality**: Protecting the community's healthReducing conventional pollutants, nutrients, and emerging contaminants • Reducing operation and maintenance costs
- **Green and sustainable Development**

The detailed cost analysis indicates that the decentralized option apart from yielding a much better effluent quality would prove to be much cheaper even if we opt for the fully automatic facility or the tertiary treatment. Thus it is recommended that this option should be explored in greater details before taking a final decision. The operating cost is about Rs. 26000-28000 per MLD sewage treatment up to secondary level treatment, which is less than that of most of ASP plants due to saving in power.

VI. WASTEWATER AND WATER QUALITY ISSUES

- Wastewater contains a number of pollutants and contaminants, including o Plant nutrients (nitrogen, phosphorus, potassium)
- Pathogenic microorganisms (viruses, bacteria, protozoa) o Heavy metals (e.g. Cadmium, chromium, copper, mercury, nickel, lead, and zinc);
- Organic pollutants (e.g. Polychlorinated biphenyls, pol- aromatic hydrocarbons, pesticides); and biodegradable organics (BOD, COD). Micro-pollutants etc.
- These can be cause for harmful health and environmental issues which may be increase economic/financial impacts in form of treatment costs to make water usable for certain purposes)
- Pros: – Conserve potable water – Reduce effluent to environment
- Cons: – Health & safety precautions necessary – Careful planning needed and Potential for much greater use in future.

The Concept Of Centralized And Decentralized Systems Waste Water Management Systems: "Wastewater management encompasses a broad range of efforts that promote effective and responsible water use, treatment, and disposal and encourage the protection and restoration of the watersheds." (Crites and Tchobanoglous, 1998).

Centralized Waste Water Management System: In India, commonly we have centralized wastewater management system. Some of its characteristics are:

- Conventional gravity sewers
- One treatment facility
- Effluent discharge directly to surface water.

Decentralized Waste Water Management

"Decentralized wastewater management is a concept in which wastewater is managed: collected, treated and disposed of/reused at or near the point of generation" (Crites and Tchobanoglous, 1998). Thus, it is also referred to as on-site management. Decentralized wastewater technologies differ from conventional centralized systems in that they "**Treat and Reuse or Dispose of wastewater at or near its source of Generation**" (Magliaro and Lovins, 2004).

The decentralized systems can be applied on different scales. It can be applied to

- Individual Households
- A Cluster Of Homes
- A Neighbourhood
- Public Facilities
- Commercial Area
- Industrial Parks
- Small Portions Of Large Communities

Decentralized Waste Water Management System

- Decentralized wastewater management system has some general characteristics.
- Onsite or cluster systems
- Multiple treatments and soil dispersal or reuse facilities
- Low-cost, shallow sewer systems for clusters.

Centralized And Decentralized Wastewater Management System: Treatment In the urban environs, the current "conventional" practice is to design large sewage treatment systems (>3500 m3/day) in order to capture the economies of scale. The entire sewage is collected at one central place through the sewerage system and treated to the degree required for the intended end use or the mode of disposal. In a decentralized system, instead of sending wastewater into a sewer system serving many homes, the water is treated and returned for reuse.

The terms "Decentralized" and "Onsite" are often interchanged. However, a "Decentralized" system also refers to the use onsite or community level systems to treat all type of the wastewater collectively generated by many homes or an entire community. Rather than operating a centralized wastewater treatment system where all sewage flows to one treatment plant, many communities today use a decentralized wastewater treatment approach under specific environmental settings. What should be the criteria/ considerations for choosing an

Decentralized Treatment Systems: Where to consider:

- Where the operational and management of existing onsite systems can be better;
- Where individual onsite systems are failed.
- Where the servicable area or facility is distant from existing sewer system;
- Where localized water reuse opportunities are available;
- Where the environmental and other issues in expansion of the existing wastewater collection and treatment.
- Where the site or environmental conditions are isolated:
- Where density of residential area is low;
- Advantages of decentralized systems Modular development possible;

- Stage wise investment strategy is easy to implement;
- Failure of individual units will not affect work at other places;
- The results of Cost-Benefit Analysis indicate a favorable situation of this option compared to the centralized wastewater treatment system
- Scope for trying different advance technology options and replicating the most efficient system based on performance feed back;
- Disturbance to public would be the minimum during construction and installation of the plants.

Economic Analysis Of Centralized Vs Decentralized System

To understand the economics of Decentralized and Centralized treatment systems, it is essential to compare the two systems for detailed cost analysis. In this chapter following costs for the two systems have been compared.

1. Capital Cost

2. Power Cost for 10 Yrs

3. O& M cost for 10 Yrs For

Common expenditure for both the systems which has not been included in calculations as it would not affect the decision:

- The cost of sump and pump to carry water from sewer to sump.
- The cost of the pipeline for abstraction of sewage from the sewer to sump.
- The cost of the separate pipeline, if any, for irrigating with treated sewage.
- Interest on capital investment.

Benefits of Managed Decentralized Systems

- ✓ Treatment of wastewater can be done at lower cost.
- ✓ The decentralized system helps in recharge groundwater aquifers.
- ✓ Decentralized system is installed as per needed basis.
- ✓ A decentralized system is having lower replacement and repair cost.
- ✓ The decentralized system provides flexible wastewater management options.

Table: Project of Decentralized Waste Water Management System in INDIA/

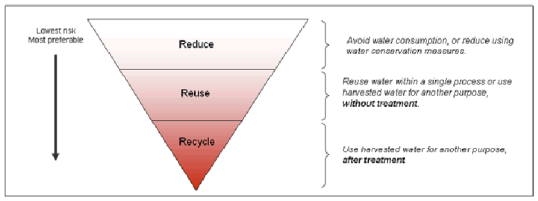
Name of project	WWT Capacity	Water produced	Area serving for green space
MCD Nursery, Vasant Vihar, Delhi	**50 KLD**	**45 KL**	**25,000 Sq.m**
Centre for Science & Environment, Institution	**10 KLD**	**8 KLD**	**1,500 Sq.m**
IIT-Delhi	**10 KLD**	**8 KLD**	**3,000 Sq.m**
Scindia School, Gwalior	**15 KLD**	**12 KLD**	**3,000 Sq.m**
Residential Home, Sec-54 , Gurgaon	**300 LPD**	**250 LPD**	**80 Sq.m**
Mehtab Bagh off Taj Mahal, Agra	**60 KLD**	**55 KLD**	**30,000 Sq. m**
Annamaye Ashram, Kasauni	**60 KLD**	**50 KLD**	**30,000 Sq. m**
Regency Park, High-rise flats, Residential complex, Gurgaon	**15 KLD**	**13 KLD**	**5,000 Sq. m**
3-star Hill Resort, RamNagar-Nainital cottage homes	**3 KLD**	**2.5 KLD**	**1,000 Sq. m**

Source: A Report of Centre for Science and Energy (CSE)-Delhi's on Waste Water Management System of Major Indian Cities

Wastewater management system of the city should be decentralized to the neighborhood level. This system would be more efficient and would be covering almost every part of the city.

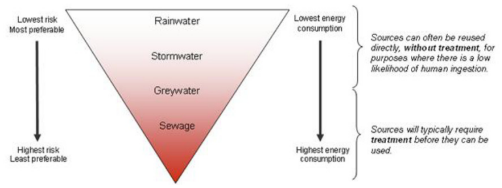
The Water Conservation Hierarchy

We should rethink for reusing low risk water resources, like rain water or storm water, before recycling higher risk source water, such as greywater and sewage.



Inherent Risk for alternative Water Sources

The following figure explain how water source affected when we moves from rainwater to storm water inherent risk and energy consumption, then grey water and finally sewage.



Source: Wastewater Management - A UN-Water Analytical Brief

3r's Theory For Urban Waste Water

The 3R's apply to water conservation and consumption:

Reduce. It means reduction or minimize the waste water genertion by decreasing water consumption, we will reduce water quantity that needs to be pumped out of the ground or moved from one location to another..

REUSE

It means maximize the reuse of generated watse water. We should reuse "grey water" by installing systems at household level. These systems capture water from devices such as faucets and shower drains and filter the water which can be re-used to wash hands, fill toilets, or even water our garden nad cloth washing.

Recycle. Recycling of water means re-using waste water after treatment. Recycled water is often being used to irrigation nad watering for gardening due cheaper than potable water.

Reusing And Recycling Water

It should be alternative water supplies is a key part of reducing the pressure on our water resources and the environment. We should choose proper water source, for minimizing, risk, resource, and energy requirements.

- Rainwater
- Grey water
- Treated Sewage
- Industrial Water
- Managed Aquifer Recharge (Mar)
- Framework For Alternative Urban Water Supplies.

The standards Norms for diposal of waste water discharges shown in Table;

Sanitary Sewage Discharges[a]		
Pollutants	**Units**	**Guideline Value**
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	MPN[b] / 100 ml	400[a]

Notes:
[a] Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation.
[b] MPN = Most Probable Number

Table: Treated Waste water Disposal Standards
Source: Central Pollution Control Board's Standards

Ways To Recycle Water At Small Scale

- **Use a Shower Bucket**
- **Install a Rain Barrel**
- **Create a Rain Garden**
- **Save Water from Washing Machines**
- **Install a Grey Water System**
- **Collect the Overflow from Watering Plants**
- **Reuse Excess Drinking Water**

Uses For Recycled Water

- Agriculture
- Landscape
- Industrial
- Public Parks
- Golf Course Irrigation
- Cooling Water For Power Plants and Oil Refineries
- Processing Water For Mills, Plants
- Thermal Power stations
- Toilet Flushing
- Dust Control,
- Construction activities like concrete mixing
- Artificial Water Bodies and Lakes

Recycled water can convince most water demands, as long as it is adequately treated to ensure water quality appropriate for the use.

- Recycling Water Can Save Energy
- Water Recycling Can Reduce and Prevent Pollution
- Water Recycling will be reduce the discharge or disposal of waste water in natural water sources.

Wastewater type	**Wastewater source**	**L/person/day**
Blackwater	Toilet	20
Greywater	Shower	63
	Hand basin	6
	Washing machine	13
	Laundry tap	2
Other wastewater	Kitchen tap	12
	Dishwasher	5
Total Grey water		**84**
Total wastewater		**121**

Environmental Benefits of Water Recycling Recycling waste and Grey water requires far less energy than treating salt water using a desalination system.

 All new single family and joint residential dwelling units should include either a separate pipe outlet or a diverter valve, installation on clothes washing machine hook-ups, to allow separate discharge of Grey water for irrigation and other purpose.

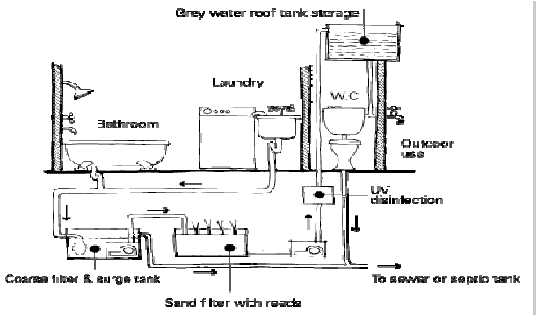
 All new nuclear family units or residential dwelling units shall include a building drain, showers, and bathtubs and all other plumbing fixtures should be connected a minimum three (3) feet from the foundation, for future installation of a distributed Grey water system

Wastewater Reuse At Individual Household: On-site wastewater reuse can decrease water use in households level of urban areas. At present, most homes use potable water for practically everything in the house and garden. We are flushing our drinking water down the toilet. Majorly two types of wastewater are generated in a home: Greywater and Blackwater.

Greywater is wastewater from non-toilet plumbing fixtures such as showers, basins, and taps.

Blackwater is water from that has been mixed with waste from the toilet. Blackwater requires biological or chemical treatment and disinfection before dipose or reuse.

Greywater is the best for garden watering, Appropriately treated greywater should be reused for toilet flushing and clothes washing,



A wastewater reuse system at household level

Source: Water Recycling and Reuse | Region 9: Water | US EPA

This type of setup can decrease demand on infrastructure for sewage transport, treatment, and disposal, allowing it to work better and last longer.

A survey report concludes result following table about amount and type of waste water generated in major Indian cities under Centre for Science and Energy(CSE)-Delhi

Table: Analysis of Amount and type of waste water generated in major Indian cities9per capita)

Source: Centre for Science and Energy (CSE)-Delhi.

VII. GENERAL RECOMMENDATIONS

The Future of Water Recycling Water has proven to be effective and successful in creating a new and reliable water supply without compromising public health.

- Precautions while irrigating with this water Preferably to be done at night so that there are no visitors; Pipes to be marked red with instructions displayed “not for drinking”.
- STP should be placed in such a location that smells, if any, do not travel towards populated areas.
- For ensuring that the treated water is up to the mark and safe Some agency (PHED Gandhi Nagar laboratory, RPCB laboratory or any NABL/MOEF/ISO accredited laboratory) can be hired for sampling and analysis at regular intervals including surprise checks;
- Provisions for alternative use of treated water can be made in the case of less demand for irrigation e.g., groundwater recharge.
- For recovering the O&M costs, we can charge people a nominal amount for visiting the parks.
- The decentralized scheme, if finalized, should be implemented in a modular manner starting with a trial of 2-3 technology options. Two or three different management models may be tried (for financing and O&M) at different locations and the best of these may be finalized for large scale replication based on performance analysis.

- ❖ The wastewater management system of any city is decentralized on the basis of administrative units.
- ❖ The wastewater management system of the city should be decentralized to the neighborhood level.
- ❖ A decentralized system would be more efficient and would be covering almost every part of the city.
- ❖ Non-Potable treated water should be reuse wide level with proper planed process.
- ❖ The observations shall be put into practice to achieve the goal of health and hygiene for citizens: Planning Strategic Guidelines for the Decentralized system in Waste Water Management System in Urban Area like:
- ⌘ At the household level, we should provide a filter for reusing grey water in toilets and bathrooms.
- ⌘ At the community level, we should provide community level recycle units to minimize the operation & management cost at lowest infrastructure & collection network cost.
- ⌘ By applying 3R's theory at the household level we will minimize the O & M cost with lower infrastructure and minimum length of collection network.
- ⌘ A Separate System: Sewerage system to carry domestic sewage while drainage system for storm water. We should aware people for providing separate pipe system at household level water supply and waste water generation.
- ⌘ Sludge may be dewatered, thickened and incinerated. Ashes remain may be used for landfill.
- ⌘ 100% households should be covered by sewerage. Water Supply service should be co-ordinated with waste water management system.
- ⌘ Water tariff should be such as to discourage the people from wasteful use of water.

VIII. CONCLUSIONS

Decentralization of waste water with proper efficient recycling and reuse process is necessary requirement toward intensive sustainable development for waste water management. Instead, centralized system we should provide decentralized system with proper Recycling process with Reducing and Reusing maximum waste water which should be more efficient, cost effective and eco-friendly solution.

REFERENCES

[1]. Sewerage, Drainage & Waste water collection network & management system data of Jaipur-City collected from RUDSICO, RUIDP, JMC & JDA-Jaipur Rajasthan.

[2]. Wastewater Management - A UN-Water Analytical Brief

[3]. Sewerage, Drainage & Waste water collection network & management system data of Jaipur-City collected from RUDSICO, RUIDP, JMC & JDA-Jaipur Rajasthan.

[4]. Waste Management - New Mexico Environment Department, Waste Management -New Mexico Environment Department, https://www.env.nm.gov/nav_waste.html

[5]. Wastewater Management - A UN-Water Analytical Brief

[6]. Guidelines for Sewerage and Drainage Policy, Rajasthan

[7]. Changing paradigm for sewage - from treatment to recycle by **AB Gupta, CSE-STPs** http://cseindia.org/

[8]. Architecting Water Supply System- A Perspective from Value of Flexibility By Stephen ZHANG1 and Vladan BABOVIC2

[9]. Development of a system dynamics model for financially sustainable management of municipal water main networks R. Rehan, M.A. Knight, A.J.A. Unger.

[10]. Financially sustainable management strategies for urban wastewater collection infrastructure – development of a system dynamics model R. Rehan a, M.A. Knight b, A.J.A. Unger.

[11]. System Dynamics Approach: A Novel Water Resource Management Tool

[12]. A System Dynamics Model for Integrated Water Infrastructure Asset Management Ganjidoost, M.A.Sc.1.

[13]. Water Recycling and Reuse Water | US EPA, https://www3.epa.gov/region/water/recycling

[14]. Karia, G L, Christian R A, Wastewater Treatment Concepts, and Design Approach, PHI Learning Pvt. Ltd., (2 Apr. 2013)

[15]. Decentralized Wastewater Treatment: Solution,https://www.epa.gov/siteproduction

[16]. McKenzie-Ray Urban Water India Final version forthcoming in Water Policy

[17]. McKinney R, Microbiology for Sanitary Engineers, New York: McGraw-Hill; 1962.

[18]. Guidelines for Sewerage and Drainage Policy, Rajasthan.

[19]. Water Technology Centre, Indian Agricultural Research Institute, New Delhi, India

[20]. Reusing and recycling waste water, http://www.epa.vic.gov.au/yourenvironment/water/reusing-and-recycling-water

[21]. Reports on Waste water Management under Centre for Science and Energy (CSE)-Delhi.