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Environmental Imperative for City Sanitation Plan: Meerut Urban Area

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ABSTRACT

The present study discusses the sanitation problems in Meerut urban area, which are caused due to various urban activities such as poor water, wastewater and solid waste management and inadequate toilet facility, which degrades the environmental quality and making it one of the filthiest urban areas in India. Due to continuous extraction and dependency on ground water for urban water supply as well as for industrial use has lead to depletion of ground water table. Inadequate sewerage system leads to flow of municipal sewage and industrial effluent into storm water drains without any prior treatment and contaminate ground water. Dumping of solid waste in vacant land is common practice as there is no scientific landfill site. The study highlights the stress area and formulates the various strategies, plans, polices and scientific approaches towards the improvement of sanitation issues including water, wastewater and solid waste management and proper channel of toilet facility which will make Meerut urban area an open defecation free, livable with a good hygienic condition and a better environment.

Keywords: *Sanitation, Open defecation, Water treatment, Wastewater Treatment and Solid Waste Management.*

1. Introduction

Meerut city in the Indian state of Uttar Pradesh is administrative headquarter of Meerut division and Meerut district. It is the second largest city in the National Capital Region (NCR), 16th largest metropolitan area and 25th largest city in India. It is 33rd most populous urban agglomeration and 26th most populous city in India [1]. It was ranked 292 and 242 in year 2006 and 2010 respectively in the largest cities and urban area in the world. Meerut Cantonment is one of the largest Cantonments in the country. Meerut Cantonment established in 1806, which was, headquarter of the seventh division of the Northern Army. The total population of Meerut urban area is 14,20,902 which constitutes Meerut City (Meerut Municipal Corporation) population is 13,05,429; Meerut Cantonment (Meerut Cantonment Board) population is 93,312 and 4 Census towns namely: Amehra Adipur, Bhurbaral, Mohiuddinpur and Sindhawali have a population of 12,161 [1]. Meerut urban area covers an area of 186.61 sq km in which 141.92 sq km area is comprised of Meerut Municipal Corporation and 4 Census towns and the Meerut Cantonment covers 35.67 sq km [1]. There are total 185 slums in Meerut urban area; out of which 114 are notified and remaining 71 are non-notified slums [2].

The total slum population in Meerut urban area is 7, 22,281 which constitutes about 51% of the urban area population. Approximately 81% of slums have existed for more than 20 years in urban area, 8% of slums are located in hazardous sites, 39% are located along major drains and 15% are located along railway line and major transport alignment. 85% of slums are located in core area of the urban area and remaining 15% of slums are located in the fringe area [2].

1.1 National Urban Sanitation Policy (NUSP), 2008

The NUSP defines Sanitation as "safe management of human excreta (including its safe confinement, treatment, and disposal and associated hygiene-related practices). It further recognizes that solutions are needed to take account of other elements of environmental sanitation, i.e., Solid Waste Management (SWM); generation of industrial and other specialized/ hazardous wastes; drainage and management of drinking water supply" [3]. The NUSP includes:

- Elimination of open defecation
- Elimination of manual scavenging and ensuring safety of sanitation workers
- Safe management of municipal wastewater and storm water
- Recycling of treated wastewater for non-potable applications
- Full and safe collection and disposal of municipal solid waste
- Inclusive, efficient and sustainable service delivery in all sanitation services
- Improved public health outcomes and environmental standards

1.2 Necessity of Sanitation Plan for Meerut Urban Area

After being the center of administrative power, the environmental quality in term of Sanitation is very poor. Meerut city has been ranked 465th out of 476, 69th out of 73 cities and 339 out of 434 cities across India in *Swachh Survekshan* conducted by Government of India in year 2015, 2016 and 2017 respectively [4-6]. This makes it one of the filthiest cities in India. The reason behind this poor performance in Sanitation is as the city lacks in management of physical infrastructure facilities such as water management, wastewater treatment and solid waste management and no proper restrictions on industries for their discharge by local authorities.

2. Material and methods

The work presented in this paper is wholly based on planning and engineering perspective; design practices and standard methods that have been used for the development of sanitation plan for Meerut urban area are as per guidelines and norms provided by the Government of India.

The study is descriptively based on existing Sanitation scenario of Meerut urban area mainly open defecation, water, municipal sewage, industrial effluent and solid waste; based on this current status highlights the main issues and stress areas in Meerut urban area and thus formulating/ prepares the Sanitation plan for the forthcoming year 2031.

Sanitation Scenario in Meerut Urban Area are given as follows

A. Water Supply

Water is the basic need for humankind for its survival, so it is our prime duty to preserve and manage the water whether it is surface or groundwater. The main source of water supply in Meerut urban area is groundwater; only 2MLD water treatment plant is built on Ganga Canal, which is a source of surface water supply. Piped water supply was introduced in Meerut for a population of about 1,16,000 in 1895 about 52 lpcd. At present, 70% of Municipal area and more than 80% of Municipal area population is covered with piped water supply and rest depends upon hand pumps, jet pumps, neighborhood and other source of water supply. While Cantonment Board has 100% of its area with piped water supply the remaining census towns are totally dependent on the ground water on their own. Areas covered by water supply are shown in Fig. 1 and supply in lpcd area wise is in Fig. 2.

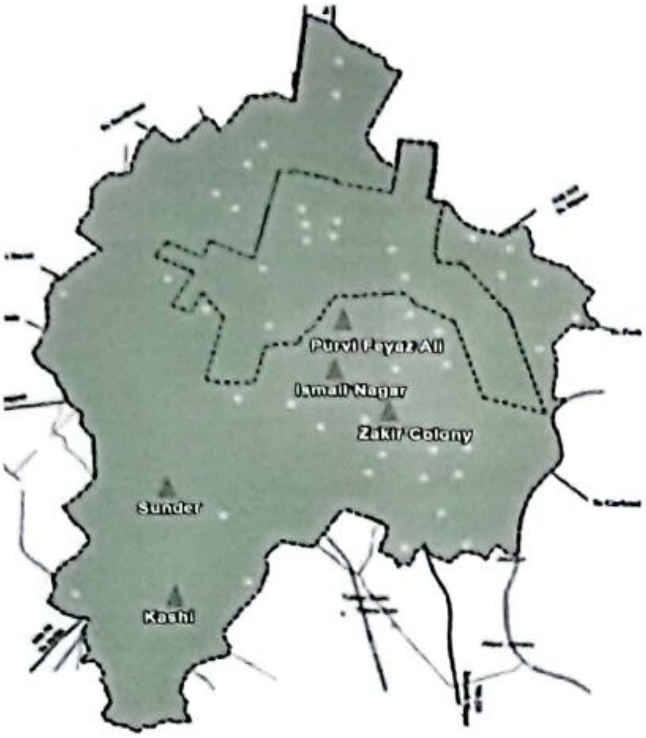


Fig. 1. Water Served Area in Meerut City

The service level benchmarks established by the Ministry of Urban Development, Government of India, for the sector of water supply attempts to compare the service levels against the five key parameters are indicated in the spider chart shown in Fig. 2. Due to increase in demand of water from various sectors (domestic, commercial, industrial, institutional and agriculture) and over use of ground water, there is depletion of ground water table and aquifer are dipping by 1m [27]. Approximately 10% of urban population does not have access to regular safe drinking water while 30% of urban and 90% of rural households depends on unsafe water sources to meet their daily needs [7].

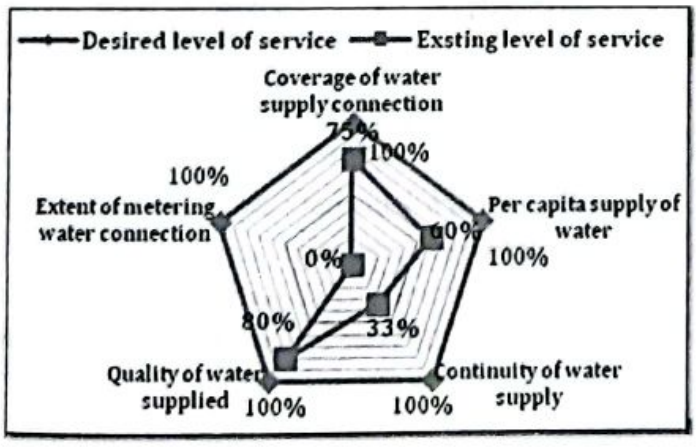


Fig. 2. Web network for water supply

Meerut suffers from a considerable gap of about 81 million litres per day (MLD) between the demand and supply of water after accounting for leakage losses [28]. The study revealed that the salinity in the city has increased at a faster rate. Iron, TDS, Total Hardness, Calcium and Fluoride were found to have values above acceptable limits of BIS standards and Magnesium found to be the only parameter which exceeded the permissible limits.

The quality of ground water is degrading day-by-day as pollutant from untreated sewage and from industrial effluents seep into the ground and mixed with the ground water; characteristics can be seen in the Table 1 [16].

Only 51.3% of people with portable water connections in poor neighborhoods get above 80% of their total water requirements [8].

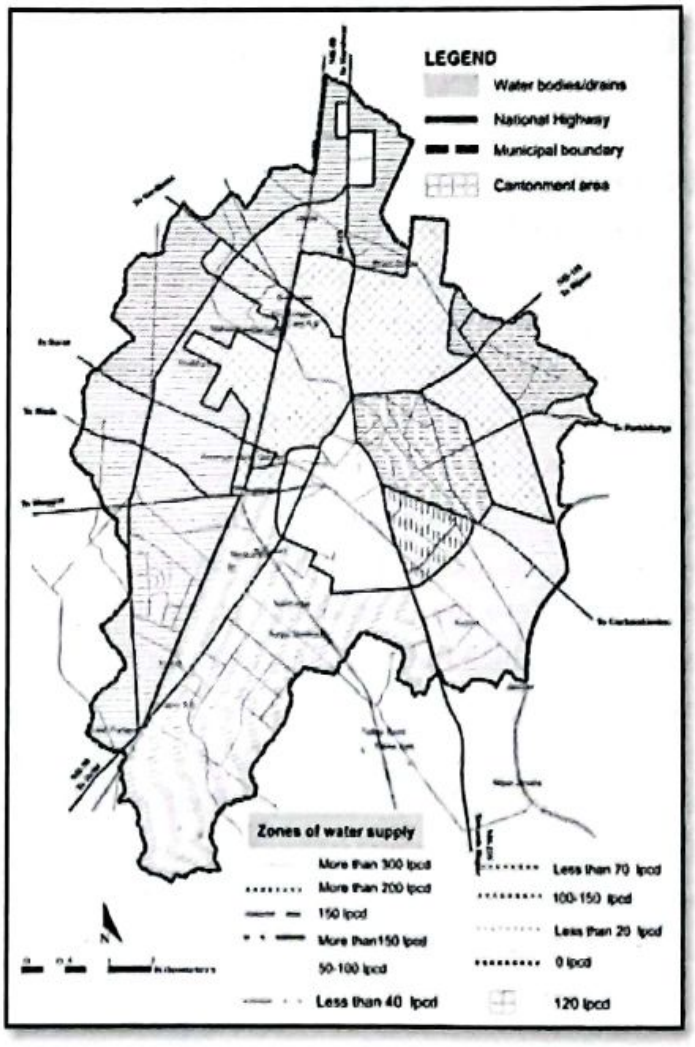


Fig. 3. Zones of Water Supply

Table 1. Groundwater Characteristics

Sampling Location/Year		pH	Total Dissolved Solids	Total Hardness	Calcium	Chloride	Fluoride	Nitrate	Magne-sium	Iron
Sunder	2011	7.17	649	157.6	54.6	111.5	1.38	18.8	163	0.42
	2012	7.42	554	225.8	89.4	53.6	0.53	10.7	106	0.57
Kashi	2011	7.30	598	174.1	77.8	108.6	0.52	12.6	147	0.50
	2012	6.85	582	222.5	76.7	82.6	0.68	18.1	94	0.63
Purvi Feyaz Ali	2011	7.12	612	248.6	79.2	109.8	0.80	40.1	110	0.50
	2012	7.10	478	123.1	46.3	78.9	1.04	19.4	108	0.35
Ismail Nagar	2011	7.53	613	209.8	89.1	75.7	0.70	15.2	100	0.35
	2012	6.95	514	183.8	69.5	105.9	0.70	15.6	77.2	0.42
Zakir Colony	2011	7.63	674	230.5	100.2	64.8	0.53	12.3	118	0.40
	2012	7.0	532	50.8	23.4	111.5	0.53	12.1	146	0.31
Acceptable limit (BIS)		**6.5-8.5**	**500**	**200**	**75**	**250**	**1**	**45**	**30**	**0.3**
Permissible limit (BIS)		**NR**	**2000**	**600**	**200**	**1000**	**1.5**	**NR**	**100**	**NR**

Source: CPCB, 2013

B. Sewerage System

Meerut urban area lacks in sewerage system as there is only 425 km of sewer line, out of which 37 km trunk line [8], whereas Meerut Cantonment area does not have sewerage system and wastewater directly flows into storm water drains without any treatment. At present, Meerut urban area generates 310 MLD of sewage while the disposing capacity is just 45 MLD. The major quantity of sewage is directly discharged into the three drains going through the urban area, which furthers joins the Kali river, finally meeting Ganga river.

The areas which are covered by sewerage system are the areas which are developed by Meerut Development Authority. The existing level of service and to the desired level of service, which was established by the Ministry of Urban Development, Government of India, is shown in Fig. 4.

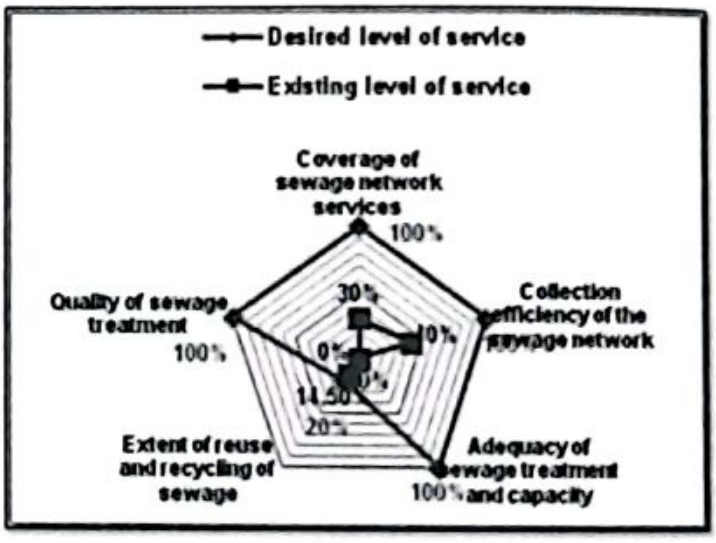


Fig. 4. Web network for sewerage system

Only 25-30% of urban population is covered by the existing sewerage system, which highlights the urgent need for the improvement of sewerage system in urban area. At present, there is no sewage treatment plant in the urban area.

Figure 5 presents the areas which are covered and un-covered by the sewerage system and location of sewage pumping station.

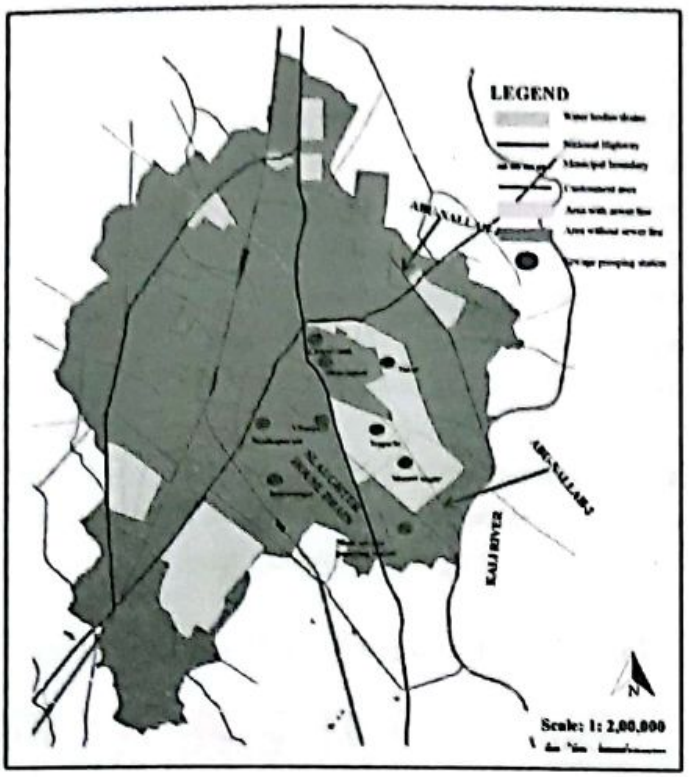


Fig. 5. Covered and un-covered sewerage system

C. Storm Water Drainage System

Meerut urban area is famous for its big open drains which cris-cross the entire length and breadth of the urban area. These drains give poor image of Meerut urban area as these drains carry the entire sewage of Meerut urban area. There are total five storm water drains namely: Abu Nala-1, Abu Nala-2, NAS Nala, Odean Nala, Khadoli Nala which are shown in Map 3. These storm water drains carry the entire municipal sewage, industrial effluent from slaughter houses and from industries without any treatment and meet with Kali Nadi in the out-skirt of the urban area; which finally meet with river Ganga. These storm water drains are also used as dumping yard for solid waste; as most of the slums lie along these drains so they face water logging problem during rainy season as wastewater from these drains spills out from these drains which leads to unhygienic and filthy living conditions and also cause water borne diseases.

Table 2. Heavy metals concentration from major drains of Meerut

Sr. No	Parameters	Results (mg/l)	WHO guidelines (mg/l)
1	Arsenic (As) mg/l	BDL	0.04
2	Cadmium (Cd) mg/l	BDL	0.02
3	Total Chromium (Cr) mg/l	BDL	0.05
4	Copper (Cu) mg/l	-	1.0
5	Iron (Fe) mg/l	1.42	-
6	Lead (Pb) mg/l	BDL	0.1
7	Manganese (Mn) mg/l	0.14	-
8	Nickel (Ni) mg/l	-	-
9	Mercury (Hg) mg/l	0.14	0.002
10	Zinc (Zn) mg/l	-	5.0
11	Cobalt (Co) mg/l	BDL	-
12	Selenium (Se) mg/l	-	0.01
13	Vanadium (V) mg/l	-	-

Source: CPCB, 2017

D. Solid Waste Management

Solid waste management is probably the most crucial aspect in Meerut urban area. The Meerut Municipal Corporation and Meerut Cantonment Board are responsible for collection, transportation and disposal of solid waste generated within their jurisdiction. As of 2011, Municipal solid waste (MSW) generation in Meerut is 804 TPD with 0.525 kg/d is the per capita generation, and presently, no waste handling techniques but area occupied by known landfills is about 14.2 ha with 2 nos. of landfills [29]. The service level benchmarks established by the MoUD, GoI for the sector of solid waste attempts to compare the service levels against the eight key parameters as indicated in the spider chart shown in the Fig. 6.

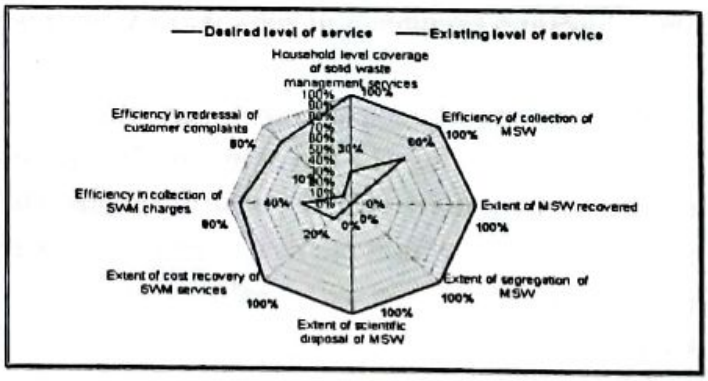


Fig. 6. Web Network for Solid Waste Management

Solid waste generated within the urban area is 910 Mt/day out of which 850 Mt/day is generated within the city and 60 Mt/day within the cantonment (Meerut Municipal Corporation, 2015). Approximately, 40% of the area under MMC is covered under daily collection and the rest under biweekly or fortnightly collection system. Fringe areas have no collection of solid waste whereas; cantonment board covers 100% area under daily collection of solid waste as shown in the Fig. 7.

The solid waste from households and industries is dumped near the roads, parks or in municipal dalaos, from where it ultimately reaches to sanitary landfill located at Delhi road. There is no proper system of monitoring the dumping activities.

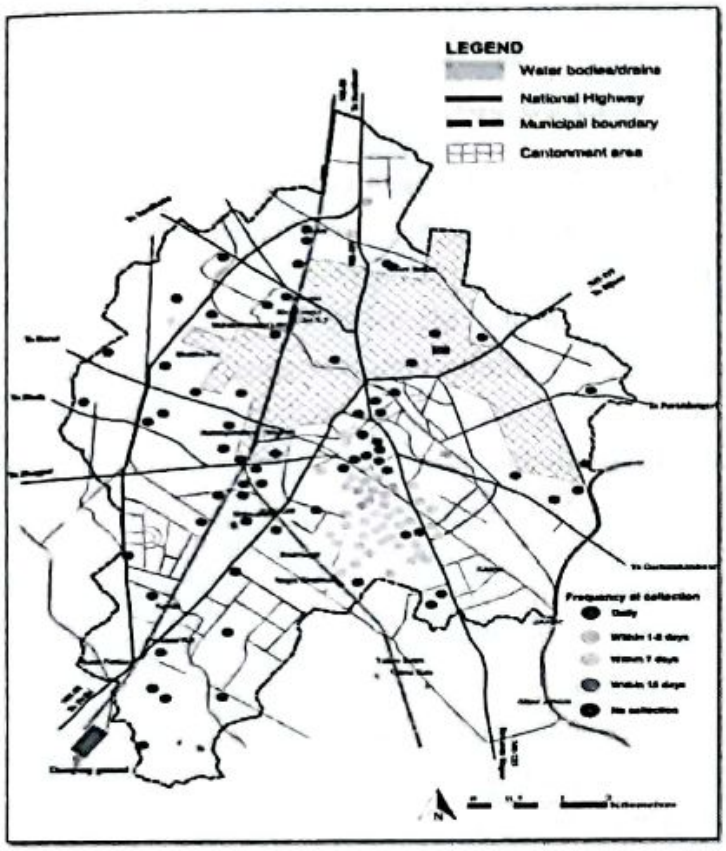


Fig. 7. Sites and Frequency of Solid Waste Collection

At present, the Municipal Corporation collects 600 Mt/day of solid waste. The rest of the solid waste lies directly on the street or it is thrown in the drains. The garbage collections from the bins is irregular. Other aspects of a normal solid waste management process namely waste storage, segregation, primary and secondary collection, waste processing, disposal and reuse and recycling of waste which are large missing in Meerut, with rampant complaints from different stakeholders about plastic and biomedical waste management.

Meerut city has a waste collection capacity of about 70% and does not have adequate transport facilities. Significant littering usually takes place while waste is stored in collection centers and during its transport. At present, all the municipal solid waste is disposed off in an unscientific way. Unscientific disposal practices leave waste unattended at disposal sites where birds, flies, rodents create unhygienic conditions (odor, foul smells etc.). Rag pickers pick up plastic content of MSW. Since, the functioning of various groups of rag pickers is not formalized, not all the recyclables, particularly plastic bags are picked up and are found littered everywhere, reaching the drains and water bodies ultimately choking them.

Table 3. Collection of Solid Waste in the City

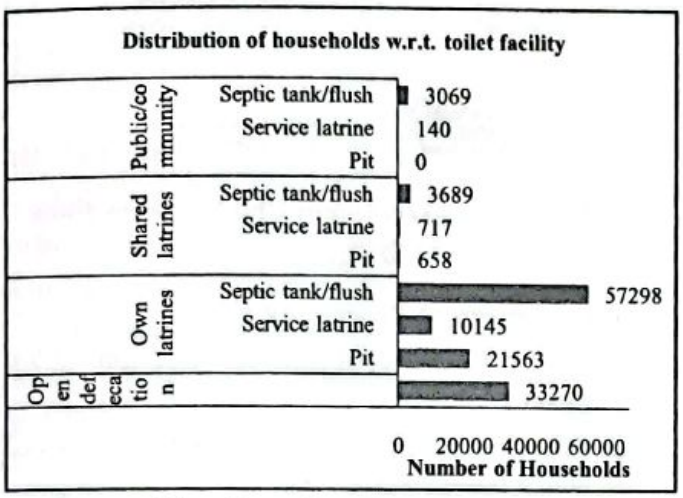
Year	1991-92	2001-02	Upto 2015
Population	8,53,294	10,74,229	13,39,023 (2011)
Total solid waste generated (MTD)	260	550	910
Per capita/day (gm)	310	450	600
Industrial waste (MTD)	723.6	-	-
Hospital waste (MTD)	-	20	50
Waste from slaughter house(MTD)	-	60	100

The waste generated by hospitals, nursing homes, health centers, laboratories, slaughter houses, veterinary institutions constitute an important component of waste management.

Access to toilet / latrine is one of the basic necessities and is an indicator use for measuring quality. In Indian context, three different types of

toilets were usually used viz., pit, service latrine and septic tank/flush. Three different ways of access to toilet was considered viz., own latrine, shared latrine and public/community toilets. In lack of access to these facilities, the practice of open defecation is wide spread.

As evident in Fig. 8, about 69 percent of the slum households have access to own latrine with septic tank/ flush/service/pit type of latrine. 4 percent of households use shared latrines and 2 percent households use public/community toilets. An alarming share of about 25 percent urban households practice open defecation, which tends to unhygienic environment and health related problems.



Source: Slum Free City Planning: Meerut City

Fig. 8. Distribution of households with respect to type of toilet use

Even though 75 percent of the households have access to some form of toilets, it is believed that existing toilet system is considered to be of primitive type with no proper maintenance and lacks general hygienic conditions, further deteriorating the environment.

E. Industries

Meerut is one of the important industrial towns of western Uttar Pradesh. It is famous for handloom works and scissors industry from old age. Meerut was one of the first cities in northern India where publishing was set up during the 19th century. It was a major centre of commercial publishing during 1860s and 1870s.

Being in the proximity of Delhi, it is ideal for industry. It is home to 520 micro, small and medium scale industries. Meerut has about 23,471 industrial units, including 15,510 small-scale units and 7,992 cottage industries as per 2008, DIC, Meerut.

Meerut urban area is home to some prominent regional pharmaceuticals companies like Perk Pharmaceuticals Limited, Mankind Pharma and Bestochem. Meerut is one of the major manufacturing regions for sports goods in India. It is especially famous for the manufacture of cricket goods with SG (Sunil Gavaskar) being the largest Indian cricket goods manufacturer and exporter operating in Meerut. It is also a hub of gold design in India. City is also the largest manufacturer of musical instruments in India. It is also home to a battle gear and armory industry, which produces gear for use in Hollywood films and television series.

Industries in Meerut are water intensive which causes environmental damage. Large-scale industries are of red category i.e. highly polluting industries. All the large-scale industries have their own effluent treatment plant (ETP) but they do not run on full efficiency or either are not working. Therefore, their effluents meet with the domestic wastewater without any treatment, which degrad(the quality of drains, carrying domestic wastewater. Large-scale industries within and nearby the urban area have influenced the urban area due to pollution of drains and river. Large-scale industries mainly are:

- ModiTyres Co. Pvt. Ltd., Modipuram, Meerut
- Daurala Sugar Works, Daurala, Meerut
- Alps Industries Ltd., Delhi road, Meerut
- Devpriya Papers Pvt. Ltd., Sani, Meerut
- UP Sugar Mill Limited
- Beer Industry

3. Results and discussion

Analysis of the current scenario of sanitation in Meerut urban area helps in assessing the major issues to be solved by the implementing scientific approach and design practices.

Strategies for Addressing "Sanitation Plan"

Projected population for Meerut urban area for 2031 is 2,039,804 calculated by Incremental Increase Method. This paper includes water treatment and management, sewage treatment and management, solid waste management and access to toilet facility for the Meerut urban area.

I. Water Treatment and Management

Total water requirement for urban population in 2031 is 449 (~450) MLD excluding the industrial demand. As the main source of water is ground water so, conventional water treatment plant can be used for the treating water of urban area. (Fig. 9)

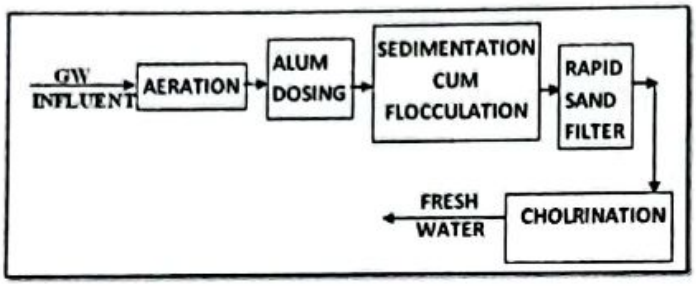


Fig. 9. Proposed Water Treatment Plant

Proposed Design Considerations: Two WTPs are required for treating water each of 225 MLD capacities.

1. *Cascade Aerator*, for providing aeration with average water required 2.5 m^3/sec and head required is 0.52 m with 6 steps of 0.3 cm size on which water shall be flowing down to outlet chamber.
2. *Alum Dosing*, for coagulation and for normal conditions alum required is 900 kg/d, whereas for peak conditions @20 mg/l is 4500 kg/d.
3. *Sedimentation Tank* dimensions designed to be 169m x 56.4m x 3.5m depth, whereas flocculation chamber to be 31.4m x 56.4m x1.8m.
4. *Rapid Gravity Sand Filter*, plan area of filter required is 1761 m^2, providing 22 filter units each of area of 80 m^2 (9.0m x 8.9m size),design flow for backwashing water (3% of filter output) and washing time (30 min i.e. time lost for back washing) comes out to be 9862 m^3/hr.
5. *Chlorination Contact Tank* of size 48m x 22m x 3m, and quantity of chlorine provided 28.12 kg/hr (capacity of chlorinator).

II. Wastewater Treatment Management

Wastewater generated is 80% of the totalwater supply, which comes out to be 359 MLD (~360 MLD) for population of 2031, thus, providing two STPs each with 215 MLD capacities (extra 20% capacity as MoEF&CC). The proposed sewage treatmentplant is shown in the Fig. 10.

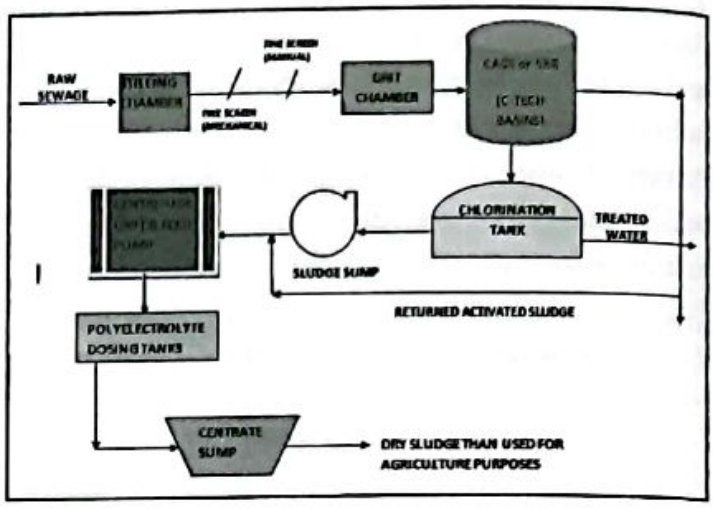


Fig. 10. Sewage Treatment Plant Process Flow Diagram

Proposed Design of Processing Units:

1. *Stilling Chamber* of size 8.50m x 5.0m x 3.5m (1 no.)
2. *Fine Screen Channel*- Mechanical (3 nos.) of size 8.0m x 1.6m x 1.5m.
3. *Fine Screen Channel*- Manual (1 no) of size 8.0m x 1.6m x 1.5m.
4. *Grit Chamber* of size 10.5m x 10.5m x 1.0m (1 no.)
5. *C-Tech Basins* (6 nos.) of size 85m x 45m x 5.20m.
6. *Chlorination Contact Tank* of size 46m x 22m x 3.0m (1 no.)
7. *Biological Sludge Sump* of size 22.5m x 9.5m x 3m (1 no.)
8. *Polyelectrolyte Dosing System* of size 2.5m x 2.5m x 2.5m (2 nos.)
9. *Centrate Sump* of size 8.5m x 2.5m x 1.6m.

(Source: CPHEEO Manual on Sewerage and Sewage Treatment Systems, MoUD, GOI, 2013)

After the treatment, treated water can be used for irrigation, groundwater recharge, and industrial

purpose and in park and open spaces and sludge can be used as manure. Wastewater treatment methods adopted are for mixed effluent (domestic and industrial) is shown in Table 4.

Table 4. Wastewater Technologies used for Existing Industries

Industrial Wastewater	Adoptable Technology
Brewery Industry	Up flow Anaerobic Sludge Blanket (UASB)
Slaughter House	Activated Sludge Process (ASP)
Sugar Industry	Up flow Anaerobic Sludge Blanket (UASB)
Dairy Industry	Up flow Anaerobic Sludge Blanket (UASB)

III. Solid Waste Management

Solid waste generated in the urban area comes out to be 1224 TPD as 0.5 kg/capita/day is the solid waste generation in the metro cities.

Proposed Design Considerations: As current waste generation is 910 Tons/day and estimated waste generated for the year 2031 is 1224 tons/day.

1. Currently, waste generation is 910 tons per day, so the total waste generation by 2031 population comes out to be 6 x 10^6 tones.
2. Total waste volume calculated as 5.1 x $10^6 m^3$.
3. Volume of daily cover in 16 years (on basis of 15 cm soil cover on top & sides of height of 1.5 to 2.0m) comes out to be 0.51 x 10^6 m^3.
4. Volume of liner and cover system would be 0.637 x $10^6 m^3$.
5. The estimate of landfill volume calculated as 5.737 x 10^6 m^3.
6. Being rectangular in plan, the area required for landfill is 1.91 x 10^5hectares ~2 Hectares, with plan dimensions of 320 m x 640 m (204,800 m^2).

Proper treatment of Biomedical and Hazardous waste can be done by Incinerators. Industrial solid waste should be used in agriculture and raw material for other industries. Method adopted for solid waste management is Integrated Solid Waste Management (ISWM); purpose to adopt ISWM is because in ISWM process waste is reduced, reuse, recover and recycled from household level to community level which ultimately decreases the load on the landfill site. Composting of organic matter can be done at household level.

IV. Access to Toilet facility in Meerut Urban Area

Type of latrine used in rural areas is double pit latrines (it is recommended so that excreta can be used as fertilizer); public/community toilets should be bio toilet.

Table 5. Design components to be proposed for the population 2031

Particular	Year(2031)
Projected population	2,039,804
Projected Households	3,777,42
Demand of public toilets	
No. of total seats (about 1 seat per 100 HH)	3,777
No. of toilet blocks (about 6 seats per toilet blocks)	630

4. Conclusion and recommendations

As far as the study and research has been done so far the major issues in aspect of Sanitation in study area which should be rectified to make a better environment are:

- Due to excessive use of ground water in various sectors (domestic, commercial, industrial, agricultural) ground water is depleting day by day.
- Ground water quality is degraded because of percolation of wastewater and leachate from dumping of waste in an open ground.
- As no sewage treatment plant exists in urban area thus, approximately 30% of municipal area is covered by the sewerage system. Wastewater generated within the urban area flows in open drains and because of this reason ground water is contaminated.
- There is no policy for rainwater harvesting, the rainwater is mixed with wastewater and is polluted.

- There is no segregation of municipal and biomedical waste. Biomedical waste is disposed with municipal solid waste without any treatment.
- In many areas solid waste is dumped into the open ground from, there is no collection of waste.
- Landfill used for disposal of municipal solid waste is not designed in a scientific manner; so it causes environmental impacts like nuisance smell, odour, pollute ground water and there is no recovery of energy from the gas produced during the decomposition of waste.
- The main issue in slum is bad infrastructure facility as slums are located more than 20 years and there is lack of sanitation facilities.

Thus, the strong recommendations must be for the policy makers, stakeholders, engineers, and urban local bodies to examine rising environmental issues and adopt integrated approach in planning, designing and implementation of sanitation projects. Some key points should be considered such as:

- Strategic planning and continuous monitoring can be a menu for different approach for good sanitation.
- Proper collection of municipal solid waste till the final disposal, as there is no such landfill site so that it is proposed within or outskirts the area/city, so that solid waste will be properly managed.
- The penalty or fine has to be imposed on the violators littering or dumping waste on nallas or in open areas.
- Water will be managed if proper audit is done in all the existing industries for discharging the untreated wastewater into drains (which are having higher permissible limits).
- The storm water drainage system and also rain water harvesting system has to be there to manage water or wastewater.
- Groundwater recharge technologies can be used in the urban area.
- The environmental and sanitation awareness programmes can also be conducted so, people know how the open defecation affects their health or how adversely sanitation can impact their health.
- Decentralized Sanitation plans have to be implemented soon for making Meerut metropolitan city as one of the cleanest city in terms of sanitation practices and management.

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