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WATER QUALITY, WASTEWATER GENERATION AND SEWERAGE SYSTEM IN URBAN AREAS: A CASE STUDY OF KANPUR CITY

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Abstract:Most of the Indian cities are located along the bank of the major rivers and their pollution poses a serious threat to the secure urban water supply. Water is one of the most vital infrastructure in the city support system and this finite resource is going to be more scarce in the years to come. It has both quality and quantity dimensions. Growing water scarcity threatens economic development, sustainable human livelihood, environmental quality and a host of other societal goals in countries and regions around the world. Urban population growth in developing countries, place immense pressure on water and land resources. It also results in the release of growing volumes of wastewater most of it untreated.

The rate of industrialisation and deterioration of water quality (both surface and groundwater) is of major concern in metropolitan cities and towns in Indian cities. Thus, Kanpur city has been selected as a study area, which is facing severe problem of water quality pollution, wastewater generation and its management

Keywords: Water quality, pollution, wastewater, sewerage system, sewerage treatment plants, Kanpur City

1.INTRODUCTION:

Most of the Indian cities are located along the bank of the major rivers and their pollution poses a serious threat to the secure urban water supply. Water is one of the most vital infrastructure in the city support system and this finite resource is going to be more scarce in the years to come. It has both quality and quantity dimensions (Ghosh, 2006). Water is also vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities. Among the various environmental challenges of that India's urban centres are facing this century, fresh water scarcity ranks very high. The key challenges to better management of the water quality in India are temporal and spatial variation of rainfall, improper management of surface runoff , uneven geographic distribution of surface water resources, persistent droughts, overuse of groundwater, and contamination, drainage, and salinization and water quality problems due to treated, partially treated, and untreated wastewater from urban settlements, industrial establish ments, and run-off from the irrigation sector besides poor management of municipal solid waste and animal dung in rural areas (Kamyotra and Bhardwaj, 2011). The present paper considers assessing the water quality, wastewater treatment status and sewerage system in Kanpur city. Water quality is the result of pollution of water resources in the city which comes from the municipal, industrial and agricultural sectors. The quality of surface water resources are low as a result of dumping of insufficiently treated and untreated sewage heavily urbanized areas.

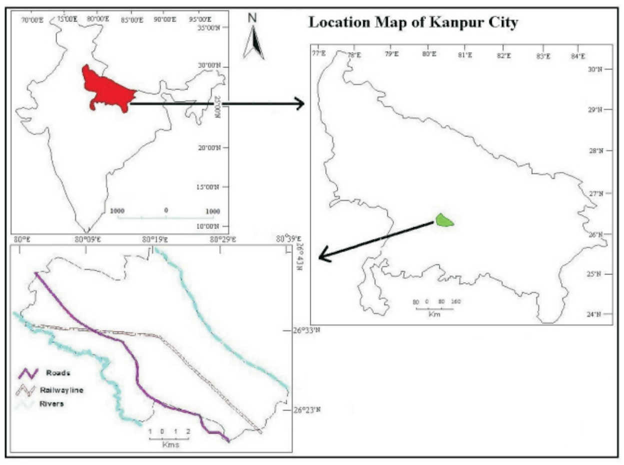
2. THE STUDY AREA

Kanpur Metropolis, the largest city of Uttar Pradesh and the eight largest city of India. It is located on western bank of river Ganga. Kanpur city occupies a geographical area of about 278 sq km. It lies between 26o20' and 26o35' north latitude and 80o10' and 80o 30' east longitude in the central part of the state (Figure 1). Kanpur city is also the largest and most populous industrial city in the State. The urban limits of Kanpur city are spread over an area of 215 sq km. The city is located between two rivers, the Ganges in the North and the river Pandu in the south. It is a linear city developed between rivers and the railway lines. Kanpur was once known as the 'Manchester of Northern India' but over the time, it has unfortunately gained notoriety as a dirty and polluted city. All the important industries such as textiles, heavy engineering, tanneries, fertilizer and leather are situated in the heart of the city with residential areas on either side.

3. OBJECTIVES OF THE STUDY

The main objectives of this paper are: (1) to analyse the water quality status in Kanpur city, (2) to understand the main sources of water pollution in the study area, and (4) to analyze and understand the status of wastewater generation with sewerage system in study area

Figure 1: The Study area: Kanpur City



4. DATA AND METHODS

The study is primarily based upon secondary sources of data. The data is collected from various government agencies and organizations. The study includes data obtained from published and unpublished records and is supplemented by information generated through literature review. The secondary data has been collected from Kanpur Jal Nigam Department, Kanpur, Kanpur Jal Sansthan, Kanpur and Office of Central Ground Water Board, Lucknow and State Ground Water Board, Kanpur and socio-economic data from Census of India Population Totals for Uttar Pradesh, 2001 etc. Information on water resources and stream water quality and source of water pollutants have been obtained from official reports of the Directorate of Ground Water and Irrigation Department of the State, Central Pollution Control Board (CPCB). Besides, books, thesis, journals, articles, newspapers, internet websites were also consulted.

5. RESULTS AND DISCUSSION

Kanpur city is the most populated town along the river Ganga in Uttar Pradesh. The city has enumerated a population of 25, 51,337 (Census of India, 2001). The decadal growth rate of population has increased from 26.5 per cent in 1981-1991 to 35 per cent in 1991-2001. In terms of population, Kanpur is the second largest city of North India after Delhi. Sixty per cent water requirements of the city are met from the river Ganga, which is badly polluted from various point and non-point pollution sources. Kanpur generates approximately 400 million litres per day (MLD) of sewage that is discharged through dozens of drains that finally opens in to the river. The stretch of Ganga near Kanpur is especially vulnerable because of inadequate discharge and flow. The Ganga in Kanpur is always spotted with human corpses and animal carcasses in addition to non-biodegradable poly bags. The ghats of Kanpur, once famous for holy dips and prayers, now lie deserted, as people have stopped bathing in this excessively polluted river stretch. The current water crisis is a clear example of urban mismanagement and poor urban planning (Mandal, 2000). The absence of storm water drains lead to flooding in the streets. At the same time, precious rainwater goes into sewage drains and flow into the already polluted river Ganga without recharging the area's groundwater. Rainwater harvesting is actually an ideal option for the city to stem the plunging water levels; improve the quality of groundwater; reduce the load on the sewage treatment plant; and reduce flooding. The water crises have occurred because the rivers are treated as a natural sewer, garbage depot and morgue.

5.1 River Water Quality of Kanpur City

The Ganga River Basin is struggling with water quality problems due to pollution from untreated sewage, industrial effluent, and urban and agricultural runoff. Pollution in the Ganga includes both domestic sewage and industrial effluents, or from both point and non-point sources. There are tremendous public health consequences for the high pollution loads seen in surface water so intimately intertwined with the livelihoods of many millions of people. People in cities and towns that receive their water supplies directly from the Ganga suffer from diarrheal diseases such as cholera as well as toxic effects from unregulated industrial effluents.

Kanpur city is the home to approximately 300 leather tanneries concentrated mainly in the Jajmau area, most of which release their effluent directly into the Ganga. Leather industries produce a large amount of effluent concentrated with pollutants, particularly the toxic heavy metal Chromium. The total sewage generated in Kanpur is around 360 MLD (million litres per day) out of which 160 MLD was proposed to be diverted to sewage treatment plants under Phase I of the Ganga Action Plan (GAP). The remaining sewage was to be treated in the second phase of GAP.

Under the Ganga Action Plan, the larger tanneries were required to install Effluent Treatment Plants, and Combined Effluent Treatment Plants. They were slate for construction to process the effluent of tanneries that were too small to afford their own plants. These goals were laudable, but difficult to achieve, and to date many of the tanneries have still not removed the chromium from their effluent before diversion to the river or the waste treatment plant. Feacal Coliform (FC) levels due to large amounts of human waste discharged into the river are also high in Kanpur and showing an increasing trend from 1897 to 2008 (Table 1). The levels FC in 1987, 1998 and 2008 are for two monitoring stations in Kanpur: Ranighat, upstream of the city, and Jajmau pumping station, which is downstream of the city. In the regions near the Jajmau area of Kanpur, poorly treated, chromium contaminated effluent is piped directly to villages for irrigation purposes.

Table 1: Average Feacal Coliform Levels (MPN/100mL)

Sampling Stations	Year		
	1987	1998	2008
1. *Ranighat*	5551	145,941.4	125,798.6
2. *Jajmau* Pumping Station	2,629,	1,500,037	2,800,876

Source: State Pollution Control Board, 2009

There is also a threat to the groundwater quality, which is becoming contaminated by surface water percolation into aquifers, leaving people with no viable source of safe and clean water, as Ganga water is the major source of drinking water for the majority of residents in Kanpur city.

Further a number of Dhobi Ghats operating permanently on the river bank contributes substantially to water pollution. The Central Pollution Control Board (CPCB, 2004-05) periodically monitors the water quality of the city at various points studied the water quality at designated sites (Table 2) The table explains the status of different parameter during different years. Water temperature and pH in all the sampling stations were within the tolerance limit, whereas Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Chloride content were exceeded the standard at various sites. It is also evident that although the situation is not alarming at all sites, but it cannot be denied that the quality of water in the stretch of Ganga passing along Kanpur is not fit for local consumption and health. Degradation of water quality creates water scarcity and limits its availability for human use and ecosystem and thereby impacts the optimum management of water resources (Rao and Mamatha, 2004).

Table 2: Water Qualities at Various Sampling Points

Sampling Points	Bithoor Ghat			Ganga Barrage (Kanpur u/s)			Rani Ghat (intake Point)			Sarsia Ghat			Buria Ghat		
	Years			Years			Years			Years			Years		
Parameters	**07**	**08**	**09**	**07**	**08**	**09**	**07**	**08**	**09**	**07**	**08**	**09**	**07**	**08**	**09**
Temperature	25.5	25.8	26.0	25.0	25.5	26.3	25.5	25.9	26.3	26.0	26.6	26.9	26.1	26.4	26.8
PH	8.4	8.0	8.5	8.2	8.2	8.3	8.2	8.0	8.4	7.8	7.6	8.0	7.8	8.3	8.0
Dissolved Oxygen	7.8	7.4	9.4	7.7	7.6	9.2	5.5	5.8	6.5	4.1	4.6	4.9	4.1	4.3	4.9
BOD (mg/l)	2.6	3.5	3.7	3.1	3.5	3.7	6.9	7.3	7.6	5.4	6.0	6.4	3.8	4.2	4.7
Total Coliform (MPN/100ml.)	7544	13692	5367	7589	4350	3300	9300	13000	15000	46000	53000	55000	21000	22000	18000

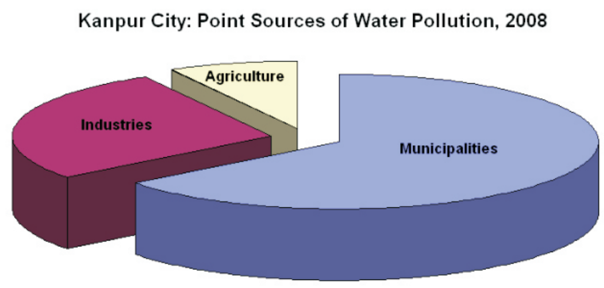
Source: State Pollution Control Board, 2009

5.2 Sources of Water Pollution

There are many sources for water pollution but two general categories are important to discuss: direct and indirect contaminant sources. Direct sources include effluent outfalls from factories, refineries, and waste treatment plants etc. that emit fluids of varying quality directly into urban water supplies. Indirect sources include contaminants that enter the water supply from soils, groundwater systems and from the atmosphere via rainwater (Kudesia, 1985).

Pollution of waterbodies is mostly from point sources such as discharge of untreated domestic sewage from the fast growing urban cities and towns located along the banks, industrial effluents etc and from non-point sources which comprises runoff from open defecation, agricultural fields, cattle wallowing, disposal of dead bodies etc using the prepared inventory, pollution load runoff from different sources has been computed basin wide. It is observed that out of total pollution load runoff reaching the river, 95 per cent is from point sources, including 65 per cent load from municipal sewage and 28 per cent load from industries and 8 per cent from the agricultural activities in surrounding areas

(Figure 2).Figure 2: Points Sources of Water Pollution



The remaining 5 per cent is contributed by non-point sources such as agricultural and forestry runoff, livestock, rural households, etc. The runoff of non-point pollution load is very small during the dry season and does not substantially affect the river water quality. However, in the wet season, the proportion of pollution load from different sources changes significantly and non-point sources also contribute a high ratio of pollutants to the river.

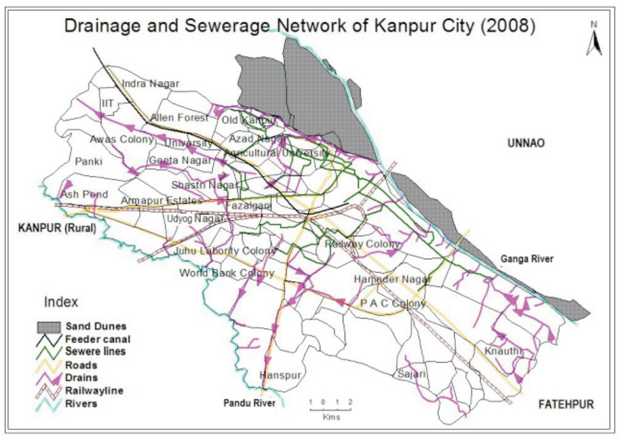
5.3 Wastewater Generation and Sewerage System of Kanpur City

Kanpur, like many other developing cities in India is facing the challenges of poor infrastructure system because of speedy urbanization. The issue of old fragmented and deteriorated drainage and sewage system in recent years has been posing a serious challenge to its governing authorities at different levels. Shortage of resources including poor finding and technology, weakness of institutional arrangement and management capacity and lack of public awareness are the major causes.

The city has developed between river Ganga on the north side and river Pandu on the south side. The total area is being 1,040 sq km. The total wastewater (Domestic and Industrial) generation is 395 MLD and the estimated water production from all sources in 2008 was 502 MLD, giving a per capita production of 140 lpcd. The total quantity of wastewater generated by Kanpur both (domestic and industrial), that coming from 26 drains (Figure 3). Wastewater is being discharged into Ganga and Pandu Rivers. Most of the wastewater is discharged into the river without treatment.

Sewerage network was laid in the year 1904 by providing the facility in a limited area. In 1920, it was extended to overcome more areas by providing trunk, main and branch sewers. The sewerage system is being administered under four different zones. There are total 13 sewage pumping stations and 30,000 manholes (Kanpur Jal Sansthan Report, 2009). Sewer lines are presently cleaned by sewer jetting machines, sewer clearing machines and also manually as per requirement.

Figure 3: Kanpur City: Drainage and Sewerage Network, 2008



Source: Kanpur Jal Sansthan Report, 2009

5.4 Sewerage Zones of Kanpur City

For implementation of sewerage works, city is divided in four sewerage districts namely:

a.District I: This sewerage district is bounded by the Ganga River to the North, HBTI and roadways workshop to the West, Armapur Estate, Dada nagar, Kidwai nagar and COD in the South. This area includes the old city core with an old sewerage network dating back to as early as 1910 and the tannery district located east of the cantonment lands.

b.District II: This sewerage district is bounded by the city district to the North, Kanpur Jhansi railway line to the West and Pandu River to the South. The Eastern boundary has been drawn to the east of Hamirpur road to include those areas that are already more heavily populated.

c.District III (West): The district is bounded by the Pandu river to the South, and the Kanpur – Jhansi railway line in north. Important localities included in this district include:

a.To the South of GT road, the Fertilizer Factory, Armapur Estate, Panki Power Generating Station, Indian Institute of Technology is located in this district

b.To the North of GT Road, Lakhanpur area, Kanpur University, HBTI

d.District IV (East): The district is bounded by the Delhi Calcutta railway line to the North, Pandu River to the South, and the city Master Plan boundary in the East. It is sparsely populated and has no sewerage system at present.

The central zone of Kanpur city has the oldest brick sewers. Brick sewers, being quite old, have lived out and are in worn out state. They have also become under due to increase in population. In densely populated area, it has become too difficult to repair these lines. Beside South of Kanpur Town, other newly developed areas such as Kalyanpur, Indra Nagar, and Vikas Nagar are also facing sewer problems. In these areas, the system is not up to the mark and proper arrangements for out fall are not there.

5.5 Status of Wastewater Interception and Treatment Network

There are 4 Intermediate Pumping Stations (IPS), one each at Nawabganj, Parmat Ghat, Baba Ghat and Guptar Ghat. Waste from these four IPS built along waste water drains, or nalas, were to be intercepted and diverted to the main pumping station through a common wastewater pipe leading to the main pumping station, which filters out solid waste and then wastewater into three Sewage Treatment Plants (STPs). Two of these plants, treat wastewater in the traditional manners, using aerobic treatment and anaerobic stabilization, and together have a waste taking capacity for 135 MLD. Sewerage system and centralised aerobic wastewater treatment plants (WTP) should not be considered as the only possible solution for sanitation. Systems with source control can avoid many problems of the endof-pipe technology by respecting different qualities of wastewater and by treating them appropriately for reuse.

The Intermediate Pumping Station at Nawabganj, is the better managed of all four because if this IPS does not run properly it would directly affect the water intake points, where two drains discharge wastewater in the dredged channel. The tapping of drains upstream of Bhaironghat is not foolproof, and the water near the intake point continues to be polluted. Instead of the installed capacity of 15 mld, this IPS is now receiving only 8 mld sewage. The Intermediate Pumping Station at Parmath Ghat though had two new DG Sets that had been setup in January, 2002. Whenever there is a power failure, sewage is often by-passed into the Ganga.

The Intermediate Pumping Station at Baba Ghat also started functioning from mid-November after a long gap when it was closed. One of the pumps is out of order and diesel supply is also not sufficient, so often sewage is by passed into the Ganga during long power cuts. The Guptar Ghat Intermediate Pumping Station remained closed since June 26, 2002; it started functioning from November 13, 2002. Currently, the IPS is working properly; the pumps are working, but the IPS is receiving less than half of the sewage than its capacity of 3 MLD. The reason for this is that the interception works on the nala is not foolproof. Even when the IPS is functioning, the nala carries a heavy load of sewage.

The Main Pumping Station at Bhaironghat receives the total city sewage and then pumps it to treatment plants. At present it is receiving much less (100-105 MLD) of sewage than its installed capacity (160 MLD). Subsequently, it pumps 5 MLD to the 5 MLD STP, 25 MLD to the 36 MLD CEPT (Common Effluent Treatment Plant) and the rest 70-75 MLD to the 130 MLD STP. The waste that reaches the treatment plants from the main pumping station is ill managed.

5.6 Sewage Treatment Plants and their Capacity

Three sewage treatments (STPs) are in operation in Kanpur. All three are located in area near Jajmau, on the eastern side of the city. In Jajmau, main sewage pumping station and treatment plants for 171 MLD capacities have been commissioned in the last decade.

5 mld (based on upflow anaerobic sludge blanket process)
130 mld ASP (based on Activated Sludge Process)
36 mld UASB (Common Effluent Treatment Plant, to treat industrial waste domestic waste).

a.5 mld UASB Sewerage Treatment Plant (STP): A pilot STP based on new technology "Upflow Anaerobic Sludge Blanket" was constructed and commissioned in 1989. This plant was designed for treatment of 5 mld of domestic wastewater.

b.36 mld UASB Sewerage Treatment Plant (STP): The 36 mld wastewater treatment plant for the treatment of waste from 175 tanneries (presently 354 tanneries) was constructed and commissioned in 1994 after evaluating the performance of pilot plant.

c.130 mld ASP Sewerage Treatment Plant (STP): This plant, based on activated sludge process, was constructed and commissioned in January 1999. This plant is designed for treatment of 130 Mld of domestic wastewater. Since its commission, illegal discharge from tanneries and industrial wastewater from various industries situated in city areas is being discharged regularly to 90 outfall sewers reaching the main pumping station from where sewerage is pumped to this plant. The tannery wastewater and industrial wastewater contains leather flushing, chromium sulphides and other toxic elements for which the STP has not been designed. Consequently the components of the equipment are corroded. The plant is now running at one-third of its capacity.

5.7 Status of Tannery Effluent

In the pre-GAP days tannery effluent from the tanneries in Jajmau used to flow unabated into the Ganga through four drains – Dabka, Bengalighat, Burhiaghat and Wajidpur, a conveyance system and four IPS were built under GAP I to collect and carry tannery effluent to the CEPT. But due to non- functioning of IPS, untreated tannery effluent is still discharged into the Ganga.

Status of 36 mld CETP: As per the first phase of Ganga Action Plan (GAP), a Common Effluent Treatment Plant for treating the wastewater generated by tanneries in Jajmau was established under the bilateral co-operation programme signed between Government of India and Netherlands government. CETP project is one part of the GAP that is meant for cleaning river Ganga and was setup in December 1994. This CETP is unique in itself that it treats homogeneous kind of wastes previously untreated into the river Ganga.

Table 3: CETP outlet standards for the treated effluent

S. No.	Parameter	Value
1	BOD (mg/1)	< 100
2	SS (mg/1)	< 200

Source: CETP Jajmau, Kanpur

5.8 Storm Water Drainage System

Kanpur city is habituated between two rivers Ganges on north and Pandu river on south. Out of 17 nalas, 14 are discharging wastewater in Ganga over a stretch of 20 km from Bithoor downstream to Jajmau. Out of all Nala, Sisamau Nala has the biggest catchments area of 1985 hectares. All the nalas, discharging in Ganga River have been tapped except Sisamau under the GAP (Ganga Action Plan) Phase – II, Sisamau nala, the largest nala in Kanpur City, presently carrying a flow of around 138 mld will be diverted for treatment. With diversion of Sisamau Nala and three Nalas already discharging into Pandu River, 200 MLD sewage treatment plant is being proposed.

6. SUGGESTIONS AND CONCLUSIONS

The important suggestions for future prospects of urban hydrology of Kanpur city are given below:

1.To improve the sanitary condition of the town, a sewerage Master Plan for Kanpur city has to be prepared considering because there is urgent need to develop the well established and concrete sewerage lines which directly take the polluted water out of the main city area.

2.The important ghats of upstream and downstream of Bhaironghat in Kanpur city should be treated through treatment plants and pollution should be removing from the Ghats.

3.There is urgent need to take the positive steps by Municipal Corporation as well as pollution control board to adopt and implement strict laws and put restrictions to discharge the polluted water without purification.

4.Inadequate use of alternative water sources. Alternative water sources other than groundwater and surface water are rarely explored.

5.Desalination is too expensive; therefore, rainwater harvesting is the only good option for small communities for remote areas.

6.Wastewater reuse may be a future alternative but it requires a better understanding on the risks and benefits of water reuse.

7.Therefore, it is necessary to adopt a new approach to water resources management in the new millennium so as to overcome these failures, reduce poverty and conserve the environment- all within the framework of sustainable development.

Action for sector improvement need to be feasible and focused on areas that can make a real difference in the future. Significant investment effort should be in the pipeline to improve situation in wastewater management sector, to provide monitoring on the quantity and quality of wastewater and renew of municipal wastewater plans. Further, it is proposed that more works should be done in this field to explore the appropriate techniques for managing water resources quality and quantity in the Kanpur city.

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