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Status of Sewerage System and Sewage Water Characteristics: A Study of Varanasi City

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Introduction

Accordng to the Centre for Science and Environment, between 75 and 80 percent of the river pollution is the result of raw sewage. Untereated discharge of waste-domestic, industrial and agricultural- and surface runoff through garbage dumping in urban centers, the quality of river water has changed quite significantly.[3] One of the major source[1] of pollution and which poses a great health risk to the mankind is water pollution. Sewage is a completely natural substance that should be broken down harmlessly in the environment: 90 percent of sewage is water. In practice. Sewae contains all kinds of other chemicals from the pharmaceutical drugs people take to the paper, plastic and other wastes they flush down their toilets. When people are sick with viruses, the sewage they produce carries those viruses into the environment.[1]

Representative of other urban populations in the developing world, residents of Varanasi, a city of over one million people in north central India, still experience major public health problems associated with sewage pollution of the Ganges River and local water supplies. In 1986, the Goverment of India launchd a Ganga Action Plan (GAP) to deal with sewage pollution of the Ganges River in Varanasi and a small number of other cities.[2] Visual observations indicated that untreated sewage continued to flow freely into the Ganges River from a variety of sewer outfalls, open drains, ditches, and other outlets, collectively referred to as point sources of pollution. Currently, there exist more than two dozen of these point sources releaing untreated sewage into the river in Varanasi. The problems at Varanasi, said to be the oldest, continuously inhabited urban centre in the world, are somewhat similar, but intensiffied by the effluents from the diesel locomotive works located in the city.

In Varanasi, an estimated 250 MLD or more of untreated human sewage if discharged into the Ganges River. River water monitoring over the past 12 years

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has demonstrated faecal coliform counts up to 10^8 MPN (most probable number) Pr 100 ml and biological oxygen demand levels averaging over 40 mg/1 in the most polluted part of the river in Varanasi. Under GAP, the Dinapur plant was designed with a sewage treatment capacity of 80 million liters daily (MLD). Tw auxiliary plants located near Banaras Hindu University and the Diesel Locomotive Works were built with a combined capacity of an additional 20 MLD. in 1986, it was estimated hat 130 MLD of sewage were being produced in Varanasi, leaving 30 MLD untreated under maximum operating capacity. According to a recent government statement (Utar Pradesh Jal Nigam internet sie 2005), the city's sewage production is now about 300 MLD, meaning that 200 MLD or more of raw untreated sewage currently enters the Ganges River. Addition to specific features of the sewage collection and treatment scheme implemented under GAP, leakage from aging and deteriorating sewer pipes is also of concern in Varanasi.

With recognition of the failure of th first phase of GAP, the Indian government has made a commitment to implement a second phase of GAP to effecively deal with industrial and urban pollution along the Ganges River. In the meantime, residents of Varanasi and other cities along the river continue to be exposed to unsafe water and associated health risks.

Study Area Profile

Varanasi or Kashi is an ancient city situated at the bank of River Ganga mentioned in Puranas and other scriptures. It is also called as KASHI meaning as the city of spiritual light. Varanasi is situated over a stretch of 6 km on the crescent shaped left bank of the Ganga. The River Ganga after traversing 1,295 km distance reaches Varanasi. Varanasi, $82^0567'$E-$83^003'$E and $25^014'$N-$25^023.5'$N) one of the oldest cities in the world and a repository o India's culture and learning since the earliest days of documented history.[5] It covers an area of about 80 sq.km. According to 2001 census, the population of the city was around 1/27 million. The riverfront and the old city is densely populated (above 500 persons/per ha). The city experienced high decadal growth of 31.6 percent in 2001. There are eighty four ghats on the left bank of the river (Sikandar and Tripathi, 1984). Most of the ghats are pucca. These ghats are used for bathing, washing, and recreation, fishing and drinkng purposes, Moreover, two ghats i.e. Harishchandra and Manikarnika are used from cremating human dead bodies. Some ghats are specially used from cleaning domestic animals and their waste disposal (Gai Ghat), some for sari printing (Lalita Ghat and Hanumangarhi Ghat) and for washing clothes by washerman (Baccharaj Ghat). At certain point sewage is dischard just near the points where from water is pumped for domestic consumption.

Naturally the population pressure on the one hand brought the civic-services infrastructure at its breaking point and on the other it has caused massive environment pollution which manifests in water, air and ground. Along with

demographic conditions, causing impact on environment, there are some other particular and speific characteristics of Varanasi which are responsible for pollution of such extreme degree. As it is one of the most aspired for city for fulfilling ones religious obligations, ritual and ceremonies, the heavey influx of pilgrim and tourists and also greatly instrumental for polluting the environment.[4]

Objective

To address sewage-related environmental problems, it is must to have accurate information and to know precisely what the problem is, where it is occurring, how serious it is, and what is causing it. Such information is necessary for determining cost-effective and lasting solutions to water-related problems. The goal is to provide appropriated picture of current sewerage system and trends in sewage water characteristics, and to facilitate the identification of emerging issued and future priorities. The prime objectives of this study are:

(i) To look into the past and existing status of sewerage system.

(ii) To sampling and analysing the sewage water and sewage outfalls at Ganga River.

(iii) To suggest major steps for control and management of sewerage system and sewage related environmental problems.

Methodology

It is based on both the primary and secondary data sources. To know the status of sewerage system of Varanasi City, secondary data have been colleted specially through the literature available from JNNURM Report as well as personal meetings by administrators, politicians, learned scholars and the local people.

Water quality has been monitored by the Dinapur STP Laboratory at several sewage outfall sites along a 7-km waterfront of the Ganges River in Varanasi, for both writer and summer seasons. Water samples for sewage outfall at Ganga River were collected in the morning between 8:00 am to 10.00 am, the period of maximum activity at the ghats. The period of sample collection was chosen from 10.12.08 to 18.12.08 for winter analysis and 28.04.09 to 10.05.09 for summer analysis. Water samples for sewage water from Konia MPS and Dinapur STP (Inlet and Oulet) were collected by Grab Sampling during the period of 21.01.09 to 22.01.09 and 04.05.09 to 05.05.09. Water for DO and BOD was collected in special bottles. All collected samples were transported in ice box to the laboratory within an hour of collection and analysed using standards methods.

Sources of Sewage Water

Improper handling of waste water is the main reason behind the pollution of water. The sewage is drained off in large quantities into rivers. It slows down the process of dilution of the constituents present in the water; which in turn, stagnates the river. Draining off the water without treatment is also a reason behing sewage water pollution.[2] These effluents contain innumerable pathogens and harmful chemicals. In the city of Varanasi, the sources of contamination of

waer are many. As the network of pipelines are parallel to sewer lines. The joints constitute the first and formost source of contamination. Secondly most of the pipes are nearly rotten by age and they often burs. Thirdly, suction is the other source of contamination although its changes are rare in the city due to regular high pressure in the supply pipes.

The excessive growth of population resulting into mushrooming of slum, inefficancy of civic amenities infra-structure, inadequate functioning of water and Sewage Treatment Plants, and Industrial effluents unscrupulously dumped into the river are the main causative factors responsible for such state of affairs. The religious practices of dumbing flowers, ash and other material emanating from worship in the temples/ or at river banks/cremation Ghats and scattering of creamation residue and immersion of dead bodies in river is also a potent cause of water pollution. The daily ebullitions of this huge population produce tons of garbage and innumerable litres of dirty and polluted water. Through smaller congested and overflowed smaller nalas/drains it pours down in bigger nalas and sewer lines. All these materials ultimately flow down in Varuna and Ganga flowing through and in middle of the town. The problem further gets compounded by more than 100 small and medium scale cottage industries which are spread over from Lahartara Industrial Estate to Shivpur, Paharia, Ashapur, Ramnagar. The industrial effluent of all these industrial are discharged in the sewer lines and other nalas and are raising the chemical pollution level to dangerous stages. Besides the smaller and big shops and commercial establishments of the city and Hotels. Restaurants directly dump their solid refuse and effluents in the river causing uncontrolled pollution in the water of the river. According to the data of Nagar Nigam there are more than 450 Hospitals, Nursing Homes, Pathologies and clincs whereing water in lakhs of litres per day is uded. Socio-cultural and religious traditions and ritual are also playing havoc with the quality of water during the seasons of festivals.

Status of Sewerage: An overview

First sewerage system in Varanasi has introduced in the year 1917 when a trunk sewer of size 30" to 90" diameter was laid from Assi to Rajghat. Another Trunk sewer known as Orderly Bazar Sewer (size 36"24", egg shaped) was laid at the same time, which joins the Main Trunk Sewer at Kabir Chauraha crossing, Since then several branch sewers were added to the system from time to time. Those systems were designed to carry only domestic waste and storm, water was to flow through 9 major open drains or underground storm water drains.

Varanasi has approximately 320 km of sewer lines and more than 75000 private connections. The 'Shahi' or 'Nawabi' drains exist in this old city which are claimd to be more than 250 or 300 years old. They are built of masonry work of brick, ston and lime and are still in use. At some places they are deep and wide

enough for and elephant through. The shapes of the sewer is generally oval, except the Trilochan ghat sewer, which is rectangular. The oval shape is made for silt trapping. The drains were essentially constructed to carry storm water but in due course of time, with the development of sewerage of the town, the sewers and domestic sludge drains were also connected to this storm water drainage system. On account of sewage gases and aging, the life of these drains is almost over as is evident from the frequent collapsing of these drains in the town raising great problems. Some of these drains have been covered up and quite a few buildings have been constructed over them, posing difficulty in their repairs and maintenance (Figure 1).

These are three disposal methods employed in the city for disposal of sewage and human wastes these are water carriage system, septic tank and conservancy system. Water carriage system serves the main portion of the city. The individual septic tanks are in some of the newly developed localities and cantonment. Some of the areas of the main city which are not severed by the branch sewers are served by conservancy system.

At Varanasi, in order to prevent pollution of river Ganga through Nawabi drains, five intermediated pumping stations has been constructed on the ghats which are known as ghat sewage pumping stations. Major drains have been connected to these pumping stations whereas outfalls of other small drains have been tapped in ghat sewers running parallel to the ghats. These ghat sewers have been connected to the aforesaid ghat sewage pumping station. Sewage intercepted through these ghats sewage pumping station is deviated to the city's main trunk sewer which is finally intercepted at Konia (Figure 2).

Konia pumping station (Figure 3) is situated in village Konia near Rajghat. Old trunk sewer having 243 mm (90") dia at the diversion manhole near Malviya Railway Bridge has been diverted by constructing a special manhole through which city sewage is diverted to Konia Pumping Station by a 286 (90") dia, 305 long bricks sewer. There exists an old sump and pump house which used to pump the raw sewage to sewage farm channel prior to the implementation of the Ganga Action plan phase-1, Raw sewage farm channel prior to the implementation of the Ganga Action Plan phase-1, Raw sewage is pumped from old pump house to the chanel of detritus from where it is degraded and finally it is pumped to Dinapur S.T.P. through second stage pumping station.

The total sewage flow from city estimated as 300 MLD. Sewage from the city and Transvaruna drainage zones is pumped to Dinapur S.T.P., from B.H.U. drainae zone to Bhagwanpur S.T.P. from D.L.W. draining zone to D.L.W. S.T.P. and from Ramnagar drainage zone to Ramnagar sewage farm.

Sewerage Zones

The city is presently divided into four sewerage zone. Three sewerage zonel, 2 (Zone 2A, Zone 2B and Zone 2C) and 3 are located within current municipal

corporation limits whereas sewerage Zone 4 is not with in the present municipal limit (Figure 4). These Districts are described as follows:[7]

Zone 1: It is the Central City sewage district draining to Dinapur STP. This area includes the old city, about 1km in breadth and 5km along the Ganga River from Assi to Rajghat. Branch sewers connecting to the old trunk sewer and the Orderly Bazaar trunk sewer cover this area. Waste water that does not enter the sewerage system follows open drains. Thse open drains discharge to Chat Pumping stations along the Ganga River. Densities in this area are very high and this area urgently requires reinforcement of branch sewers and household connections.

Zone 2: Zone 2A is the sub-central district on the CIS-Varuna side west of the ity centre and Zone 2B is a slice of the Trans-Varuna district along the Varuna River up to the ridge line defined by the Jaunpur road. Wastewater in these two zones will be collected at Chakaghat MPS. Wastewater that does not enter in to the sewerage system follown natural drainage patterns and discharging in to the Varuna River and Assi Nala. In this Distrrict, many new colonies have been developed but there is no sewerage system. In a few localities branch sewers were laid and have either been connected to the old trunk sewer of to open drains. Densities in this area are generally greater that 500 persons per hectare therefore this area should be sewered as soon as possible.

Zone 2C: is the Trans-Varuna district north of the jaunpur road. Waste water in this area generally falls to the north east direction. This area is experiencing rapid growth and projected populations indicated that densities will be much greater that 120 persons per hectare before 2015 therefore this area should be sewered as soon as possible.

Zone 3: It is the BHU/Assi district south of the City. At present this area is mainly the Banaras Hindu University campus. Which is fully sewered. The other areas around and near the campus up to the riverbank are developing rapidly. Only one sewer was laid for Lanka area. There is development of residential colonies beyond Municipal Corporation limits leading to Ramnagar pontoon bridge and Bhagwanpur village behing the university campus. The area between DLW and University is already built up but there is not sewerage system. Wastewater discharged in this area follows natural drains flowing into Nagwa/old Assi Nala and Nakkhi Nala.

Zone 4: It covers manduwadeeh, Shivdaspur and Lohta area out side the present municipal limit. These areas are fully urbanized and sewerage failities are proposed after the year 2015.

Some of the Problems Identified Regarding Sewerage System are as follows:

* The existing sewerage system is inadequated with 70% area of the city uncovered with sewer system leading to discharge of untreated sewage in open drains polluging River Ganga and Varuna.

* Capacity of STPs is inadequate to treat the existing sewage leading to disposal of untreated sewer into River Ganga and Varuna thus polluting the river water.
* Combined system of disposal putting more pressure on the system and STPs especially during the rainy sesason.
* Present sewer infrastructure including sewer network (branch/main/trunk sewers), and pumping stations is old and renovation/rehabilitation is required.
* Frequent clogging of sewerage system due to combind sewer and storm water drainage and waste dumps, especially during monsoons.
* Considering the huge quantum of wastewater being discharged into the Rivers of Varanasi, namely River Ganga, Varuna and Asi, there is an urgent need to intercept the flow of wastewater into these water bodies to prevent further pollution.

In Varanasi, for instance, even as Ganga clean-up work is going on, a World Bank-aided drinking water project is comming up that will add another 100 MLD to the city's sewage. But there is no provision to deal with this extra load in GAP's Varanasi segment and so, the water will low untreated into the river. Cities along the Ganga are all expanding rapidly but their officials give little thought to civic infrastructure, which these Municipal bodies would not be able to set up in any case because they are improverished.

Sewage Water Characteristics

Characteristics of sewage water can be known by analyzing the various amounts of pollutants present in sewage water which were sampled from Konia MPS and Dinapur STP Inlet and Outlet and Sewage Outfalls at Ganga River. Table 1 and 2 show the conventration of various pollutants in sewage water at different times in the day for summer and winter analysis. For winter analysis, the concentration of BOD and COD were maximum 200 mg/L and 360 mg/L at 8-10 a.m. while BOD minimum at 160 mg/1 at 14:00-16:00 and COD at 260 mg/1 at 16:00-18:00. For summer analysis, the concentration of BOD and COD were maximum 180mg/1 and 340mg/1 at 8-10 a.m. while BOD minimum at 160 mg/1 at 14:00-16.00 and COD at 250 md/1 at 10:00-12:00. In the morning BOD and COD were maximum due to maximization of faecal matter and domestic wastes.

The table 3 and 4 show the temperature of sewage discharged into Ganga varied from 21.0 + 0.5^{0}C in January to a maximum 36.0 + 0=5^{0}C in the month of May. The pH ranged from 7.0 + 0/1 to 8.1 + 0.1. The highest value of total coliform (MPN) was recorded a 240 at Rajghat and the lowest 160 at R.P. Ghat in winter. The DO values ranged from minimum 1.10 mg/1 at Rajghat to a maximum 4.0 mg/1 at Assi Ghat. The values of BOD (at 20 ^{0}C for 5 days) were usually higher durng the month of summer and lower in rainly season. It ranged from a minimum 120 + 20 mg/1 to a maximum 600 + mg/1 at Rajghat. It was usually lower at Assi Ghat drain. The lowest concentration of chloride as 12 + 1.0 mg/I

was recorded at Assi Ghat and the highest 100 + 1.0 mg/I at Rajghat. The polutants are found more in summer in comparison to winter because of concerntration of sewage water and reduction in the flow of water (Figure 5 and 6).

Table 1
Varanai City
Disribution of Pollutants in Sewage Water on 22.01.09

Sl. No.	Pollutants (mg/I)	8:00-10:00		10:00-12:00		12:00-14:00		14:00-16:00		16:00-18:00	
		Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
1	TS	1200	400	1600	450	980	580	800	385	650	200
2	TSS	620	35	580	40	460	60	320	32	580	28
3	Fixed Solid	460	280	320	300	500	230	280	160	255	100
4	Nirtrate	0.04	0.04	0.04	0.03	0.04	-	0.04	-	0.04	0.04
5	Nitrite	0.006	0.008	0.008	0.006	0.04	0.02	0.08	- 0.04	0.04	
6	Chloride	140	100	180	130	135	100	128	95	100	86
7	DO	Nil	4.0	Nil	3.6	Nil	3.6	Nil	4.2	Nil	4.4
8	BOD	200	30	180	40	190	35	160	28	180	26
9	COD	360	100	280	92	300	80	360	88	260	76

Source: Field Survey, Dinapur STP Laboratory, 2009.

Table 2
Varanai City
Distribution of Pollutants in Sewage Water On 04.05.09

Sl. No.	Pollutants (mg/I)	8:00-10:00		10:00-12:00		12:00-14:00		14:00-16:00		16:00-18:00	
		Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
1	TS	1000	250	1200	400	850	460	800	424	600	180
2	TSS	600	40	540	35	480	60	300	28	520	32
3	Foxed Solid	440	300	360	280	450	300	300	180	260	120
4	Nitrate	0.02	0.02	0.04	0.02	0.03	-	0.03	-	0.02	0.03
5	Nitrate	-	-	0.006	-	0.02	0.01	0.06	-	0.06	0.06
6	Chloride	10	80	140	100	126	92	135	100	120	95
7	DO	Nil	4.4	Nil	3.8	Nil	3.6	Nil	4.0	Nil	4.2
8	BOD	180	26	170	35	180	30	160	30	190	40
9	COD	340	90	250	85	280	70	300	80	280	96

Source: Field Survey, Dinapur STP Laboratory, 2009.

Table 3
Varanai City
Physico-Chemical Characteristics of Ganga Water at Sewage Outfalls

Sl.	Sampling Stations	Temp °C		pH		DO (mg/l)		BOD (mg/l)		COD (mg/l)		Chloride (mg/l)		MPN (00)	
		Air	water	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS
1	Assi drain	20	21	7.43	8.08	1.0	4.0	200	100	320	160	12	28	90	180
2	Shivala drain	20	21.5	7.28	8.01	Nil	3.20	150	500	200	320	20	50	92	180
3	Harishchandra	20	21.5	7.10	7.62	1.0	3.11	100	580	160	360	35	60	60	160
4	Chawki drain	20	21	7.17	7.58	1.0	3.25	130	600	200	400	30	90	98	185
5	Dashaswemdh	20	21.5	7.19	8.12	1.0	3.28	100	450	80	200	21	59	80	160
6	R.P.ghat drain	20	21.5	7.15	7.95	Nil	3.30	120	500	80	220	25	60	75	160
7	Jajesan drain	20	21	7.21	7.90	1.0	3.10	100	460	88	220	30	65	90	185
8	Trilochan	20	21	7.19	8.01	1.0	3.26	100	480	84	220	35	80	80	180
9	Rajghat drain	20	21.5	7.22	7.91	Nil	1.10	175	600	100	400	30	99	160	240

Source: Field survey, December 2008. (Dinapur S.T.P. Laboratory)

Table 4
Varanai City
Physico-Chemical Characteristics of Ganga Water at Sewage Outfalls Summer Analysis

Sl.	Sampling Stations	Temp °C		pH		DO (mg/l)		BOD (mg/l)		COD (mg/l)	
		Air	water	US	DS	US	DS	US	DS	US	DS
1	Assi drain	42	36	7.0	7.19	Nil	0.8	200	180	400	360
2	Shivala drain	43	34	7.11	7.23	Nil	1.0	160	120	360	320
3	Harishchandra	42	35	7.21	7.30	Nil	Nil	180	140	320	300
4	Chawki drain	42	35	7.31	7.40	Nil	Nil	110	300	300	280
5	Dashawmedh	42	36	7.21	7.30	Nil	Nil	100	320	260	240
6	R.P. ghat drain	42	36	7.16	7.26	Nil	Nil	140	400	280	260
7	Jalesan drain	43	35	7.40	7.50	Nil	Nil	140	120	280	220
8	Trilochan	42	34	7.11	7.19	Nil	Nil	160	120	360	300
9	Rajghat drain	43	36	7.31	7.40	Nil	Nil	120	140	280	220

Source: Field survey, May 2009. (Dinapur S.T.P. Laboratory)

Note: US=Upstream, DS=Downstream.

Control and Management

From the foregoing analysis it is apparent that the results of parameters chosen for the present study are within the tolerance limits. The fndings of earlier studies (Agrawal et al. 1976; Ralph, 1983 and Singh, 1986) reveal that although due to the increased population and its domestic and other activities on the river side coupled with growing household industries the quantum of urban and industrial discharge have persistently risen, yet to our satisfaction, it is well within the dissimilation capacity of the river.

The pollution arising out of this bank side activates need to be tackled immediately, NGO's role is important in developing public scariness for preventing pollution from above mentioned non-point sources of pollution. People of Varanasi city against pseudo enrironmentalists and self styled experts who have been gaining popularity by misleading the public with false and distorted facts towards executed in Varansi under GAP-1[4]. Finally, a long comprehensive programme should be chalked out for the improvement of entire Ganga basin ecosystem. In no case untreated urban industrial waster should be poured into the river from any nook and corner. Only then the life-generating properties of the mother Ganga may be restored. It is hoped that genuine professionals having both expertise and experience would assess the situation independently and play a contructive role towards mitigating the environmental pollution in Varanasi. Further studies are needed on the analysis of water quality for other priority pollutants and monitoring the area of influence in Ganga River at Varanasi.

River Ganga remains highly polluted even after being declared the 'National River' by the Central Government. The Gangal wa declared the 'National River' to facilitate th clean up operations. A Ganga River Basin Authority was also set up in order to check pollution in the river and its degradation. However, this important issued of basic civic amenity is not attrracting the attention of political parties and their leaders, who are spending most of ttheir time in the city.

Concluding Remark

Varanasi is responsible for one-forth of UP's contribution of pollutants to the Ganga and its 400-km sewerage system, some stretches of which are 300 years old has been choked since about 1920. It may be mentioned here that merely 50% of the cis-Varuna area of the city (that included old city and that areas) are covered with underground sewage pipeline, while all of the trans-Varuna areas is yet to be covered with network of sewage pipeline under the Jawaharlal Nahru

National Urban Renewal Mision (JNNURM) project.[7] In Varanasi, for instance, even as Ganga clean-up work is going on, a world Bank-aided drinkng water project is coming up that will add another 100 MLD to the city's sewage. But there is not provision to deal with this extra load in GAP's Varanasi segment and so, the water will flow untreated into the river. Cities along the Ganga are all expanding rapidly but their officials give little thought to civic infrastructure, which these municipal bodies would not be able to set up in any case because they are improverished.

It's important that the Indian government and authorities and realize the importance of taking immdiate action. It's essential that the water needes to be treated in order to prevent people from falling ill and spreading diseases. Involvement of the highest authorities of the country is important. Further educating the people in order that they don't contribute to the already existing pollution, it will definitely ensure that no more waste is added to the polluted waters.[8]

Polluted or not, the Holy Ganges is a place where people will contue to visit, due to the religious significance attached to it. It's critical that authorities take action now, or the condition is only going to worsen.

References

1. Ajmal, M., M.A. Khan and A.A. Nomani, (1983) Pollution in the river Ganges (India). Water Sci. Techno. 16: 347-358.
2. APHA (1992) Standard Methods for the Exa,omatopm pf Water and Wastewater 18th ed., American Publkic Health Association. Washington, DC.
3. Hammad. S. (1992). Development of Sewerage System and Prevention of Pollution to River Ganga. A Seminar on Pollution Cntrol of River Cities of India: A Case Study of Varanasi, SMF, Varanasi.
4. Kumra V.K., Sngh J. and Nag P., (1997) Geography and Environment: Local Issues Vol. III. Concept Publishing Company, New Delhi, India.
5. Michell., George and Singh, Rana P.B. 2005. ds. Banaras: The City Revealed. Marg Publs., Mumbai. ISBN: 81-85026-72-6: LC: 2005-318067.
6. Pandey M. Environmental pollution ontrol in Varanasi : Present status and future propcts Presented at International Conference on Statistical Inference, Combinatorics and Related Areas, Dec. 18-21, 1997.
7. JNNURM (2006) JNNURM Report for Varanasi City 2006, New Delhi, India.
8. Wang, H. (2005), 'Probe on controlling of water pollution and its relative problems' Journal of Natural Science of Hanan Normal University 28 (1): 84-87.

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