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Environmental Impact Assessment of Water Resources and Urbanization in Varanasi District, U.P., India

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Abstract: *According to the 2011 census, Varanasi district has a population of 3,676,841 and the population density of 2,399 inhabitants per square kilometer (6,210/sq mi). The sex ratio of Varanasi was 909 females for every 1000 males, and literacy rate was 77.05%. The exponential growth of the population has been recorded 17.15% in the population of 2011 as compared to census 2001. There was 25.14% increase in population recorded in 2001 as compared to census 1991, where the large-scale emigration from rural areas to urban areas, degrading the water quality and depleting the Water Resources in the district. The surface drainage and underground aquifer system have been disturbed by the large-scale urban infrastructural development activities. Due to heavy population and over-exploitation of water resources, the data of 2015-16 is analyzed to know the change in water quality due to a rapid increase in population. The various parameters like pH, Conductivity, Chloride, Alkalinity, Calcium (Ca^{++}) Magnesium(Mg^{+}), Sulphate (So_4), phosphate (P), and Nitrate (No_3) shows that water quality is deteriorated due to overexploitation and unscientific management.*

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I. Introduction

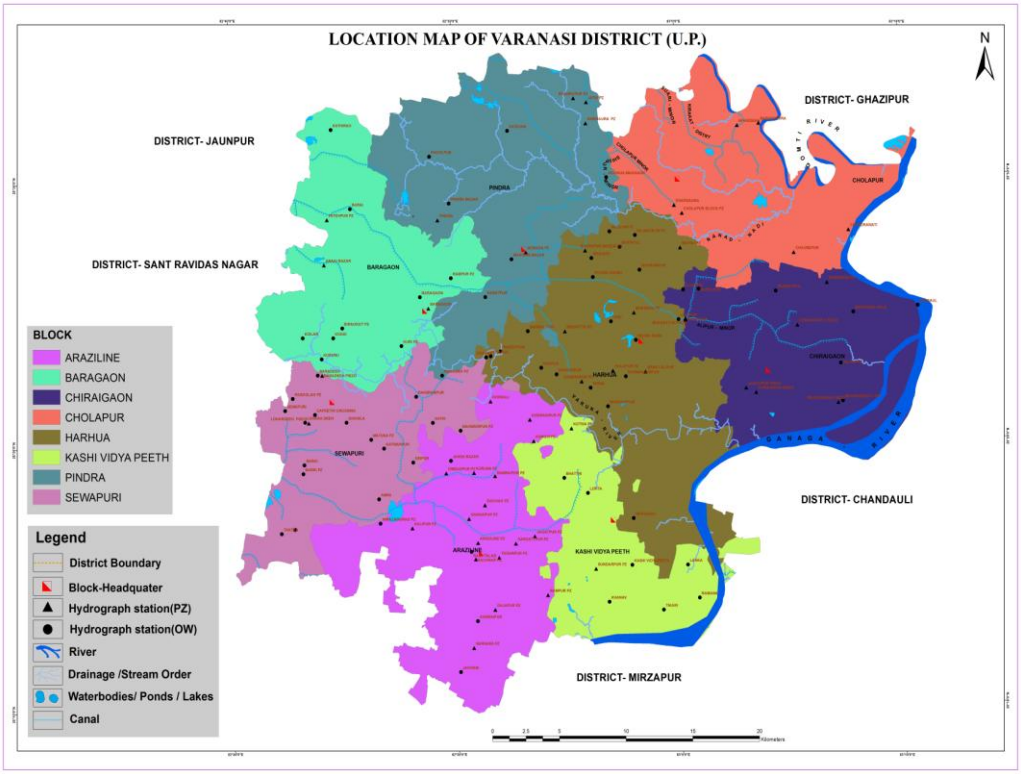
Varanasi one of the ancient cities and seat of learning in India is located on the left bank of the most sacred river Ganga. Varuna and Assi are the two streams bounding it from north and south. The city seems to have acquired its name from the combination of the names of these two streams and the district named after it. In medieval times, this name was corrupted to Banaras and it remained as such until May 1956, when it was changed to Varanasi. Being a great religious center of Hindus, it is visited by millions of people every year and so is the reason that it finds a mention in several ancient sacred texts like Puranas, Mahabharata, and Ramayana. Besides Hinduism, Buddha and Jain dharma have also flourished on this sacred place. Buddha believed to have founded Buddhism here around 528 BC when he gave his first sermon, "The Setting in Motion of the Wheel of Dharma", at nearby Sarnath. The city's religious importance continued to grow in the 8th century when Adi Shankara established the worship of Shiva as an official sect of Varanasi. Despite the Muslim rule, Varanasi remained the center of activity for Hindu intellectuals and theologians during the Middle Ages, which further contributed to its reputation as a cultural center of religion and education. Goswami Tulsidas wrote his epic poem on Lord Rama's life called Ram Charit Manas in Varanasi. Several other major figures of the Bhakti movement were born in Varanasi, including Kabir and Ravidas. Guru Nanak Dev visited Varanasi for Shivratri in 1507, a trip that played a large role in the founding of Sikhism. In the 16th century, Varanasi experienced a cultural revival under the Muslim Mughal emperor Akbar who invested in the city and built two large temples dedicated to Shiva and Vishnu, though much of modern Varanasi was built during the 18th century, by the Maratha and Bhumihar kings. The kingdom of Banaras was given official status by the Mughals in 1737 and continued as a dynasty-governed area until Indian independence in 1947. Varanasi grew as an important industrial center, famous for its muslin and silk fabrics, perfumes, ivory works, and sculpture. Ghats of Ganga is perhaps the holiest spots of Varanasi, are full of pilgrims who flock to the place to take a dip in the holy Ganges, which believed to absolve one from all sins. There is number of temples on the bank of the Ganga River in Varanasi. It believed that people cleansed physically, mentally and spiritually by Ganga.

The Ramnagar Fort, near the eastern bank of the Ganges, built in the 18th century in the Mughal style of architecture with carved balconies, open courtyards, and scenic pavilions. Among the estimated 23,000 temples in Varanasi are Kashi Vishwanath Temple of Shiva, the Sankat Mochan Hanuman Temple, and the Durga Temple. The Kashi Naresh (Maharaja of Kashi) is the chief cultural patron of Varanasi and an essential part of all religious celebrations. An educational and musical center, many prominent Indian philosophers, poets, writers, and musicians live or have lived in the city, and it was the place, where the Benares Gharana form of Hindustani classical music was developed. One of Asia's largest residential universities is Banaras Hindu University (BHU).According to the 2011 census Varanasi district has a population of 3,676,841. The district has a population density of 2,399 inhabitants per square kilometer (6,210/sq mi). Its population growth

rate over the decade 2001-2011 was 17.32%.Varanasi has a sex ratio of 909 females for every 1000 males, and a literacy rate of 77.05%.

1.1Study Area

Varanasi lies between Latitude N 25°18'00'' to N 25°18'34''and Longitude E 82°59'00'' to E 82°59'18''. The district bounded by Gazipur in the north, Mirzapur in the south, Jaunpur and Sant Ravidas Nagar in the west and Chandauli in the east. The Varanasi district is a segment of South-eastern part of Uttar Pradesh. It lies between latitude falling in a survey of India Toposheet 63K and O. It is enriched with highly fertile soil. Jaunprur and Gazipur District surround the northern part. Mirzapur district is in the south, Chandauli district in the east and Bhadohi district in the west. Latitude 250 00' to 250 30' N and longitude 820 40' to 830 33' E. Ganga river forms the natural boundary of the eastern part of the district. The shape of the district is about to circular. It is well connected by air, rail and road to Delhi and other important cities. The district has a very good network of all-weather roads connective all the tehsils and blocks headquarters as well as the majority of the village with the headquarters.



Location Map of the Study Area

Geo-Environmental Parameters:-

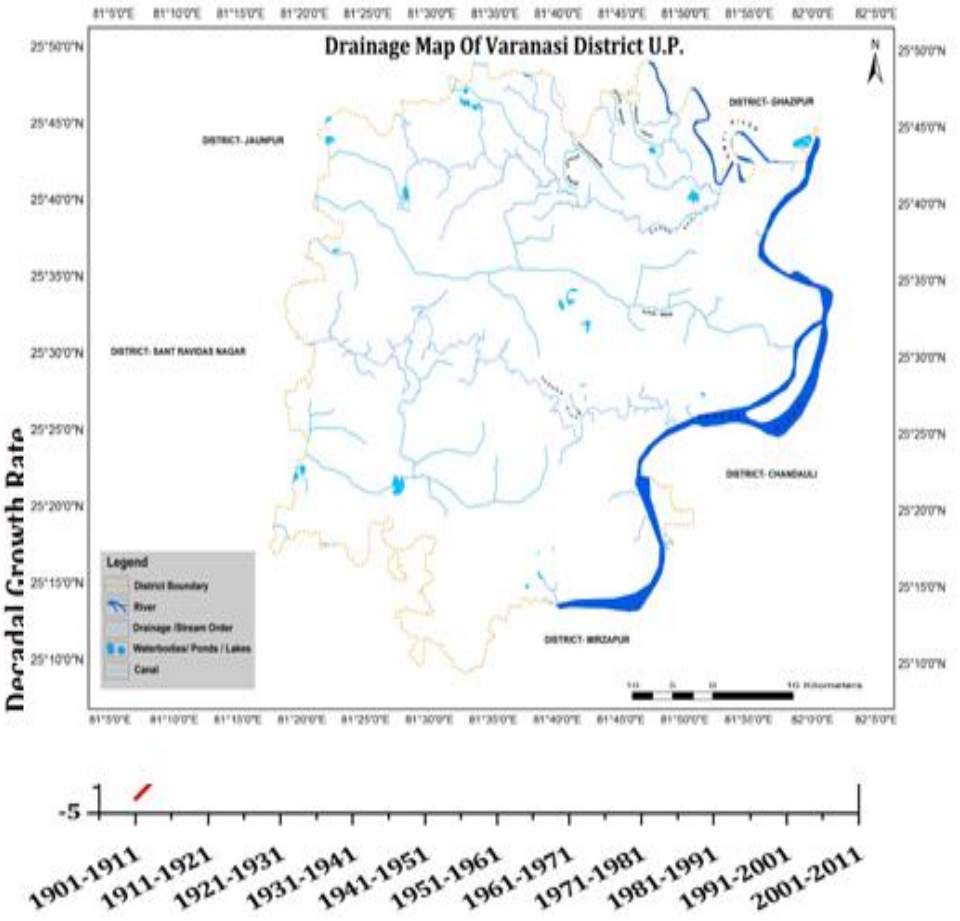
Demography of Varanasi District

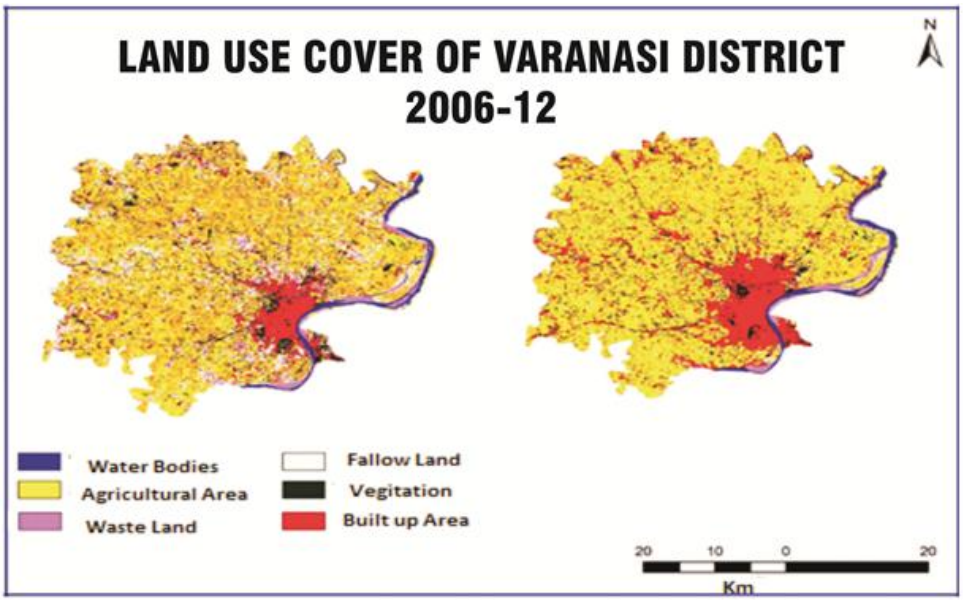
During the three early decades (1901-1921), the population of the city declined mainly due to several unfavorable factors like poor harvest, droughts, and irregularities of weather, floods, epidemics and the post-war effects of the World War I. In fact, during 1901-1925, Varanasi was one of the most deadly cities in northern India recording high population and unsanitary conditions. Since 1921, the city has recorded constant growth of population. It is recording a growth up to 31.33 percent in 1981-91. During 1901-11, the total growth rate was 0.5 percent, while it reached by average up to 18.06 percent during 1931-51, the closing impacts of World War II had also encouraged city-ward march of the population. The post-war developments, the influx of rural population for employment and immigration of refugee population were responsible for a very rapid growth. This tendency had continued till 1971. However, again during 1971-91, the growth rate became slightly higher, mainly due to the impact of the tendency of rural to urban migration in search of better livelihood and employment opportunities in the city. The city is also upgrading as a metropolis, in 1991 by recording population over a million. After that in 1991-2011, the decline in the growth rates took place because of the division of the district and due to the division, migration towards the newly formed administrative and business centers.

Year	Decadal Variation		
	Rural	**Urban**	**Total**
1901-1911	1.4	-3.6	0.5
1911-1921	1.3	3.2	1.6
1921-1931	6.3	10.8	7.1
1931-1941	18.4	19.8	18.6
1941-1951	13.9	39.8	18.5
1951-1961	15.7	33.1	19.45
1961-1971	18.06	29.58	20.76
1971-1981	26.71	38.79	29.75
1981-1991	30.75	32.91	31.33
1991-2001	29.57	19.95	25.51
2001-2011	10.91	26.87	17.32

Drainage System of the area:

The physical shape of any area is mainly decided by the drainage pattern. Ganga River with its tributaries, Gomti and Varuna forms the drainage pattern of the study area. The Ganga River is an important source of drinking water as well for irrigation. The existing water bodies are extracted through Remote Sensing data. The Ganga River, the main drainage line of the study area, is flowing from the eastern side of the Varanasi city. The river flows towards the east in Araziline development block and takes a turn towards the north where the city of Varanasi is located on a high platform formed of pebbles and Kankar. The Varuna, a perennial river, divides the Varanasi district into two parts and joins the Ganga near Sarai Mohan, east of Varanasi city after flowing for nearly 40 km through Akohra, Kundi, Gaharwar, and Koirajpur villages. It has no important tributary excepting the Bisuhil. Throughout its course, the Varuna River has a fairly high bank which is scoured on either side by numerous ravines. Assi is a small local rain-fed stream, the old historical southern boundary of Varanasi, highly polluted and congested, chocking due to encroachment. Now due to an enormous load of pollution, the river Assi has been turned into "Nallah" i.e. a sewer -line. The Ganga, Varuna, and Assi are the three natural streams which finally receive the stormwater flows into the city of Varanasi.





Landuse Pattern

`Land Use denotes how humans use the biophysical or ecological properties of land. Land-uses include the modification and/or management of land for agriculture, settlements, forestry and other uses including those that exclude humans from land, as in the designation of nature reserves for conservation. As we can see in the land use map that how much Buildup area has been increased from 2006 to 2012. This much increase in population is directly affecting the water level and water quality of the district.

Land Use & Cover Map of the Study Area

Water Recourses:-

Water resources are limited in the study area but demand or the growth of the population is not limited. It is increasing continuously. So, the efficiency of water use is also increasing that why, On the basis of water demand and use, there is a classification of the blocks as Over-exploited, Critical, semi-critical and Safe.

Critical & Non-Critical area-

S.NO.	BLOCKS	Data Source: CGWB Category (Safe/ Semi-Critical/Over Exploited)
1	ARAJILINE	OVER-EXPLOITED
2	BARAGAON	SEMI-CRITICAL
3	CRAIGAVON	SEMI-CRITICAL
4	SOLAPUR	SEMI-CRITICAL
5	HARUNA	OVER-EXPLOITED
6	KASHI VIDYAPEETH	SAFE
7	PINDRA	CRITICAL
8	SEWAPURI	SAFE

Water Quality Index of Varanasi:-

There are 26 samples are taken from the study area in 2016 and analyzed for the Water Quality Index (WQI). Horton (1965) defined Water Quality Index (WQI) as a reflection of the composite influence of individual quality characteristics on the overall quality of water. In this study, 10 parameters were chosen for the calculation of WQI. It has been calculated by using the standards of drinking water quality recommended by WHO, BIS and ICMR. The weighted arithmetic index method has been used for the calculation of WQI of the groundwater. Further quality rating or sub-index (Q_n) was calculated using the following formula.

$$\mathbf{Q_n = 100 \times [(V_n - V_{i0})/ (S_n - V_{i0})]} \qquad \text{- (1)}$$

Where,

Q_n = quality rating for the n^{th} water quality parameter.
V_n = estimated value of the n^{th} parameter at a given sampling station.
S_n = standard permissible value of n^{th} parameter

V_{i0}= ideal value of the *nth* parameter in pure water.

V_{i0} = ideal value of the n^{th} parameter in pure water. (i.e. 0 for all other parameters except the parameter pH and DO (7.0 mg/l and 14.6 mg/l respectively)

The unit weight (W_n) was calculated by a value inversely proportional to the recommended standard value (S_n) of the corresponding parameters.

$$\mathbf{W_n = K / S_n} \qquad \text{- (2)}$$

Where,

$\mathbf{W_n}$ = unit weight for n^{th} parameter
$\mathbf{S_n}$ = standard value for n^{th} parameters
K = proportionality constant.

The overall water quality index was calculated by aggregating the quality rating with the unit weight linearly by using equation (1) and (2) we have

$$\textbf{Water Quality Index (WQI)} = \sum (q_n \times W_n) / \sum W_n \qquad \text{- (3)}$$

Parameters	Observed Value (mg/l)	Standered Value (Sn)	Ideal Value (Vio)	Unit Weight (Wn)	Quality Rating (qn)	Wn*qn	WQI
Na	86.5625	200	0	0.0094	43.2813	0.4047	
Ca	62.9136	75	0	0.0249	83.8848	2.0915	
Mg	41.3906	50	0	0.0374	82.7811	3.0960	
Cl	69.4049	200	0	0.0094	34.7025	0.3245	
HCO3	**450.1198**	150	0	0.0125	300.0798	3.7410	
SO4	32.8839	200	0	0.0094	16.4420	0.1537	
EC	**1050.3214**	300	0	0.0062	350.1071	2.1823	**72.1400**
Ph	7.5144	8.5	7	0.2200	34.2952	7.5450	
TH	**327.8024**	100	0	0.0187	327.8024	6.1299	
No3	26.2002	45	0	0.0416	58.2226	2.4195	
Total				**∑Wn=0.38**		**∑Wn*qn= 28.088**	
Water Quality Index of Varanasi District, 2016= ∑(qn×Wn)/∑ Wn= 72.14							

WQI and status of water quality (Chatterjee & Raziuddin, 2002)

Water quality index Water quality status

0-25	Excellent water quality
26-50	Good water quality
51-75	**Poor water quality**
76-100	Very poor water quality
>100	Unfit for drinking

II. Results And Discussions:-

Metals and Minerals are not synthesized in the body. Their requirement for the body is obtained from food grains and water. Any impairment in the body ultimately caused serious ailments and thus causing ecological impact in the area. There are some places where few elements are present in excesses and moderate in quantity, which can cause several health hazards. Bicarbonate (HCo3), Electrical Conductivity (EC) and Total Hardness (TH), all these three parameters are interdependent. The primary source of bicarbonate (HCo3) in groundwater is the dissolved CO_2 rainwater. Electrical Conductivity (EC) indicates the ionic concentration in Water. It is represented in micro level. The conductivity depends on temperature; concentration and type of ions present (Hem, 1985) and Total Hardness of water refers to the soap neutralizing power of water, while soap is precipitated primarily by calcium and magnesium ions, hardness is defined as the sum of concentration of these ions expressed as mg/l. of CaCO3. If the concentration of HCO_3 and Electrical Conductivity (EC) is high then it will increase the Sodium Absorption Ratio (SAR) value, which decreases the productivity of the soil and degradation of water quality. According to the Water Quality Index (WQI), the water quality index of the District is 72.14, which is in the **Poor Water Quality Zone.**

III. Conclusions

Some parameters like CaCO3, HCO_3 Electrical Conductivity (EC) and Total hardness are in increasing limits as per BIS norms. Higher values of certain chemical constituents at certain locations indicate that the groundwater in those specific locations is not suitable for drinking purposes. These high values of certain inorganic parameters may be due to geological reasons or anthropogenic unplanned sewage system and

dumping of solid waste etc. The results suggest that the contamination problems are alarming at present and it will deteriorate with time.

Acknowledgement

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