Water Resources Management and Sustainable Development of Sikandra-Rao Town (U.P.)

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Abstract: In this paper an effort is made to examine the quantitative and qualitative efficacy of existing water resources of Sikandra Rao town and seven of its adjoining villages in fulfilling the water requirement of the region. To accomplish the task, various data collected from the town officials namely; Lekhpal and Qanoongo (Sankhiki Patrika, Janpad Hathras). were processed and analyzed The quantity-wise and quality-wise outcome of this study reveal that all the existing water resources of the area under study are sufficient to meet the current water requirement of the people except the pond waters, which have alkalinity, chloride concentrations and Total dissolved solid concentrations at an alarming state. Measures are proposed for quality management of the these water resources.

Index Terms- Water resources, Sustainable development, Water quality, water requirement and availability and water quality standards.

Sustainability of Existing Water Resources of Sikandra Rao Town, District Hathras, U.P., India - A Case Study

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1 INTRODUCTION

Water is a precious natural resource, vital for sustaining all life on the earth. Water, has been used for different purposes, namely for drinking, domestic, irrigation and industrial, mainly depends on its intrinsic quality hence it is of prime importance to have prior information on quality and quality of water resources available in the region, while planning developmental projects. The value of surface as well as groundwater lies not only in its wide spread occurrence and availability but also in its consistent good quality, which makes it an ideal supply of drinking water. Assessment of water quality is very important for knowing the suitability for various purposes**.** Due to its multiple benefits and the problems created by its excesses, shortages and quality deterioration, water as a resource requires special attention. The rapid growth of urban areas has further affected the groundwater quality due to over exploitation of resources and improper waste disposal practices have further made sustainable management of water resources a complex task to achieve throughout India (Scanlon et al, 2002).

Therefore, sustainable planning and management of water resources has become a priority consideration for the economic and future welfare of the country.

During the past few decades the stress on the availability of water is growing and its quality is deteriorating. The water resources sector is

presently encountering a series of interlinked issues which if not dealt in totality may prove to have serious ramifications in the long run (Kerr and Ganesh,2001). Population explosion, unpredictable rainfall pattern, natural calamities and climate change further affect water resources. It is common knowledge that there is no life without water; the reference is not just water but safe water. As far as Land management is concerned, more and more uncultivable lands can be transformed into cultivable land by employing soil conservation measures, however, optimal use of this land for irrigation is merely possible without water (Maria, 2004). Therefore, effort should be made to make available an ample quantity of water for the irrigation of lands for sufficient food production. In addition to this, water is an important element for other essential purposes like, navigation, hydroelectric power generation, industrial and not the least for domestic requirements, (Halkidiki, 2001; Kalf, et. al. 2005; Rajankar et. al. 2009).

A number of studies concerned with water resource management has been carried out across the country *viz.* Santhana Bosu (1999), V.P. Gupta (2000), Pradhan et. al. (2001), Rani et al (2003), Salunkhe (2007), Shrivastava et. al. (2007), and have suggested various solutions and techniques for water conservation via direct rain water conservation, *in-situ* moisture conservation, water harvesting and using irrigation technology for harvested water and through agronomic and engineering measures. Water crisis is not a temporary phenomenon to be dealt with in a crisis management style. It requires long terms and lasting solution beyond the short term of decision makers in office, (Wim van der Hoeck, 2001).

Pure and safe water in sufficient quantities is primal to human health (Wim van der Hoeck, 2001 and Chatterjee et. al. 2006), considering this to be a fundamental objective along with the

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present scenario of population explosion across the country, a case study has been taken up to evaluate the water resource potential and quality of Sikandra Rao town and seven of its adjoining villages so as to propose efficient water management strategies for sustainable development in and around the study area.

2. DATA ACQUISITION

Field visits were planned on regular basis of Sikandra Rao town (district Hathras, U.P.) and seven of its adjoining villages; namely Faridabad, Nagla Jalal, Navli, Umraopur, Ratimanpur, Mahamahi and Rampur to collect the data regarding availability and quantity of water resources in the study area, total land areas, population and cattle density, average annual rainfall, irrigation as well as domestic requirements and standards of living of the people in the area. To have an insight of the perspective water resource locations within the study area, a topographic map was acquired from the block development office (BDO) at Sikandra Rao town and is shown in Fig. 1(a). Other details like population of town and its adjoining villages, irrigable land, non-irrigable land, barren land, soil type, amount of rainfall, revenue collection, total area of town and villages etc. were also acquired from the BDO. Fig. 1(b) depicts all the major water resources of the town like canal, ponds, tube wells, wells, hand pumps, and municipal tanks. The map indicates a total of four ponds (each having an average capacity of 0.4 hectare-meters of water), one canal having a discharge of 15 m^3/s, 15 wells, 30 tube-wells, 1000 hand pumps in the town. Apart from these water resources, map also revels the town boundary, Kachcha and pakka houses, vacant plots, schools, telephone exchange, hospitals, railway station, mosques, temples etc. From these details, the standards of living of the people of Sikandra Rao town and their daily usage of water resources could be assessed.

To measure the water quality in the study area, water samples were collected from underground sources (*i.e.*, tube wells and hand pumps) at varying depths of 12m, 18m, and 30m. Samples were also collected from ponds, lakes and canals located within the study area. These samples were tested in the Environmental Engineering laboratory of Civil Engineering Department, A.M.U., Aligarh for alkalinity, total hardness, chloride, fluoride, arsenic, nitrate concentrations, pH and Total Dissolved Solids (TDS), and compared with the standards of drinking and irrigation proposed by Bureau of Indian Standards (BIS) so as to assess the quality of existing water resources.

Details of the data collected from town officials namely; Lekhpal and Qanoongo, Tehsil Sikandra Rao, utilized in the present study are given in Table 1(A,B) and pictorial illustration of the sites visited are illustrated in Fig. 2. Also, for the purpose of exemplification, scanned reprints of the same details are reproduced in Fig. 3.

TABLE 1. (A)

DETAILS OF DATA COLLECTED FROM SIKANDRA RAO TOWN AND ITS ADJOINING VILLAGES

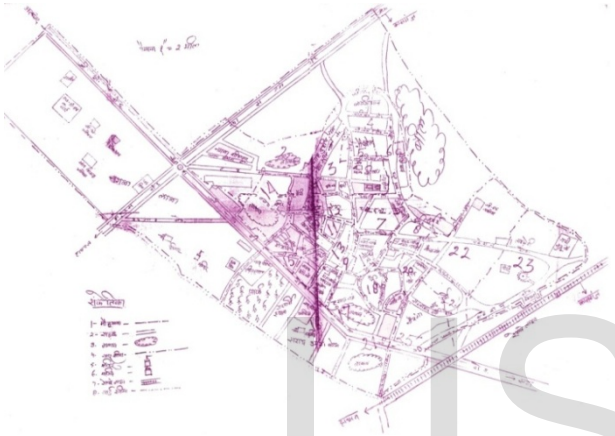
Town/Village	Sikandra Rao	Faridabad	Nagla Jalal	Navli
Area (Hectares)	26523	312	250	250
Population	136542	7622	3800	3600
Sources of Water				
(a) No. of canals	-	-	-	-
(b) No. of ponds	-	-	1	-
(c) No. of tube-wells	6	13	9	12
(d) No. of wells	5	7	6	9
(e) No. of Hand Pumps	51	65	68	71
(f) Municipal water tank	-	-	-	-
Land Use Distribution (Hectares)				
(a) Total land	26523	312	250	250
(b) Irrigated land	17425	209	186	176
(c) Non-irrigated land	8598	76	54	60
(d) Gardens	346	20	10	9
(e) Barren land	154	7	4	6
Depth of water table (m)	7.3	7.1	7.1	7.2
Amount of rainfall (cm)	65	65	65	65

TABLE 1. (B)

DETAILS OF DATA COLLECTED FROM SIKANDRA RAO TOWN AND ITS ADJOINING VILLAGES

Town/Village	Umraopur	Ratimanpur	Mahamahi	Rampur
Area (Hectares)	279.26	375.75	517.9	350
Population	4897	7622	12000	10712
Sources of Water :				
(a) No. of canals	-	-	-	-
(b) No. of ponds	-	-	1	-
(c) No. of tube-wells	6	13	9	12
(d) No. of wells	5	7	6	9
(e) No. of Hand Pumps	51	65	68	71
(f) Municipal water tank	-	-	-	-
Land Use Distribution (Hectares)				
(a) Total land	279.76	375.75	517.9	350
(b) Irrigated land	187	251	347	235
(c) Non-irrigated land	80.26	116.5	154.5	98
(d) Gardens	8.5	6.35	11.2	13
(e) Barren land	4	2	5.2	5
Depth of water table (m)	7.1	7.1	7.2	7.1
Amount of rainfall (cm)	65	65	65	65

(a)



(b)

Fig. 1(a) Topographic map of Sikandra Rao town and its adjoining villages (b) detailed topographic map showing the locations and quantity of major water resources of Sikandra Rao town and itsadjoining villages.

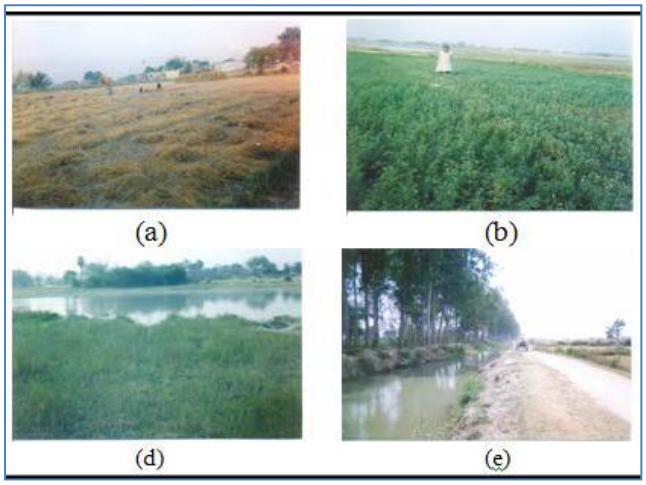


Fig. 2 Photographic illustration of the sites visited for data collection (a) Wheat crop harvesting at Umraopur village
(b) Fodder plantation at Navli village
(e) Canal passing from Sikandra Rao town to Navelli village
(d) Surface water storage at Rampur village.

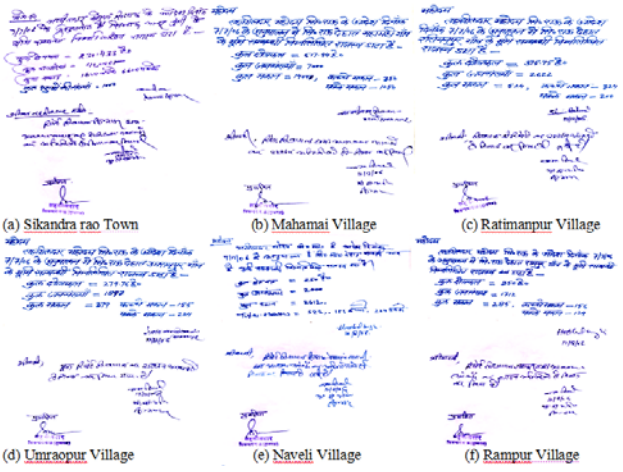


Fig. 3 (A) Data Collection from Town Official

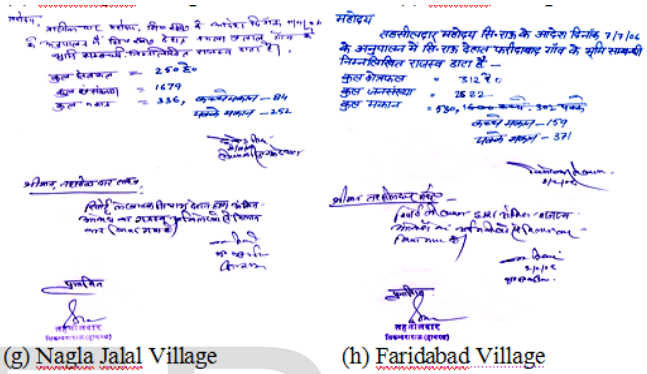


Fig. 3 (A) Data Collection from Town Official

3.0 Assessment of Existing Water Resources And Its Uses

The availability and quantity of existing water resources of Sikandra Rao town and seven of its adjoining villages was assessed by utilizing the data collected through regular *in-situ* surveys. Details of the major existing water resources of Sikandra Rao town and adjoining villages and their utilization for various purposes are summarized in Table 2 and a brief discussion is carried through in this section.

The groundwater availability for Sikandra Rao town and adjoining villages was assessed by considering the groundwater availability per unit area of the entire Hathras district multiplied by the individual areas of the study regions/villages. On the basis of Central Ground Water Board (CGWB), Ministry of Water Resources (India) statistics 2009, replenishable groundwater potential for Hathras district was considered as 66010.66 Ha-m (CGWB, 2009). The district extends to an area of 1800.1 sq-km. The groundwater potential of adjoining villages is replenished form the net water groundwater available for Sikandra Rao town (Table 2.). A 12 km extent canal (Gore wali Canal) passes through the southern part of Sikandra Rao town

helps the farmers for irrigating the fields. The measured bed-width of the canal is 7.2m and has an average water depth of 1.3m. The average discharge through the canal ranged to 15 m^3/s, from which, the canal water potential per annum has been evaluated. Similarly, the averaged water availability of a total of four ponds in the town was reckoned on the basis of data collected from BDO and was taken as 1.6 Ha-m. Data regarding crop area under different seasons served in quantifying the water requirements of different crops.

3.1 WATER QUALITY ASSESSMENT

The quality of water in the study area was gauged by carrying out the laboratory tests against the various standards of water purported by the Bureau of Indian Standards (BIS). Groundwater samples from three different depths (12m, 18 m and 30 m) as well as surface water samples from ponds and canal were analyzed for alkalinity, total hardness, chloride, fluoride, arsenic, nitrate concentrations, pH and Total Dissolved Solids (TDS). Results of the laboratory analysis are provided in Table 3 and as bar charts in Figures 4, 5, 6 and 7.

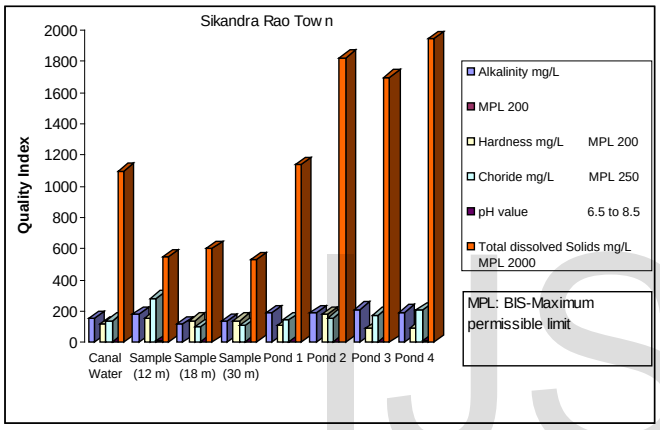
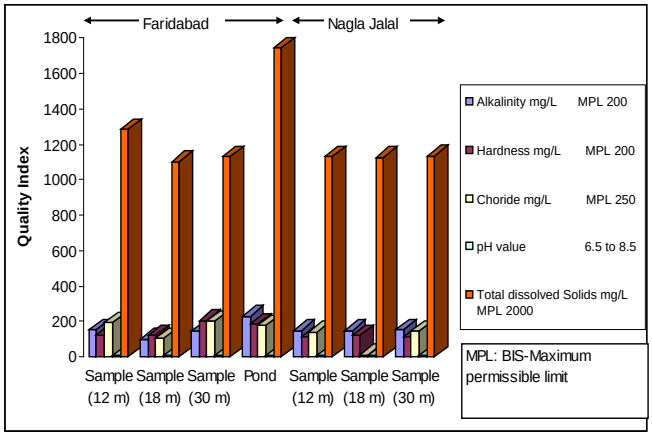


Fig. 4 Qualitative Analysis of Existing Water Resources of Sikandra Rao Town.



The domestic water requirements of the residents within the study area such as, drinking, washing and bathing have been assessed on the basis of per capita demand of the person per day. The water requirement of a single person per day (as per Indian Standard Specification, ISI standards) for Sikandra Rao town (semi-urban) is 135 liters per day and a value adopted for adjoining villages is 70 liters per day (rural). Likewise, the cattle water demand per day per cattle is considered as 15 liters per day (ISI standards)

Fig. 5 Qualitative Analysis of Existing Water Resources of Faridabad and Nagla Jalal Village.

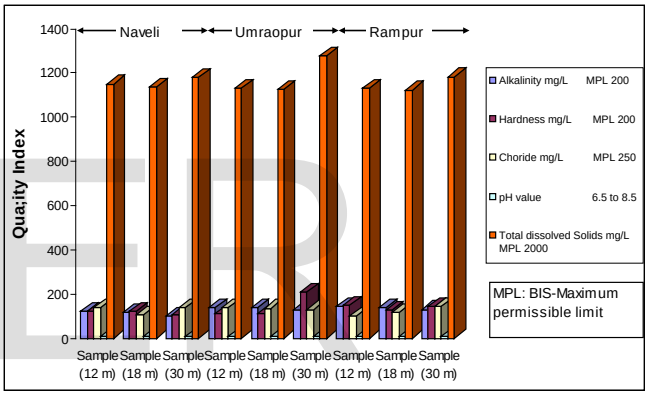


Fig. 6 Qualitative Analysis of Existing Water Resources of Navli, Umraopur and Rampur Village.

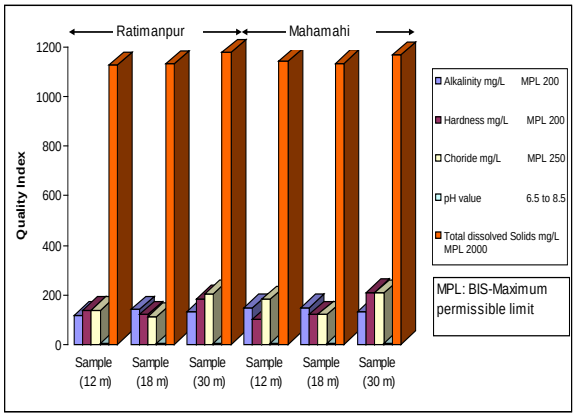


Fig. 7 Qualitative Analysis of Existing Water Resources of Ratimanpur and Mahamahi Village.

4.0 RESULTS AND DISCUSSION

Results of quantity and quality assessment of water resources potential of Sikandra rao town and seven of its adjoining villages are presented in Table 2(A,B,C), Table 3(A,B,C) and Figures 4, 5, 6 and 7. A comparison between gross existing water resources of the study area and the total water requirements for irrigation as well as domestic purposes has been carried out and summarized in Table 4.

TABLE 2 (A,B,C)

Details of Existing Water Resources of Sikandra Rao town and Adjoining Villages and their Utilization for Different Requirements

TABLE 2 (**A**)

I Irrigation Requirements for Rabi and Kharif crops				
		Kharif Crop		
	Sikandra-Rao	Faridabad	Nagla Jalal	Navli
Maize	16.83	22.59	31.23	21.15
Bajra	16.83	22.59	31.25	21.15
Juar	08.42	11.30	15.65	10.58
Pulses	02.81	03.77	05.21	03.53
Rice	19.63	97.89	135.2	91.65
Vegetables	07.48	10.04	13.88	09.4
		Rabi Crop		
Wheat	6511.6	58.52	47.04	44.96
Gram	06.60	03.14	02.52	02.45
Potato	2423.2	21.70	13.44	13.44
Sugarcane	795.20	18.81	15.12	12.65
Vegetables	304	08.36	06.52	06.52
Total Irrigation Requirements	**14506.20**	**272.80**	**175.36**	**174.61**
II Domestic Water Requirements				
Drinking, washing & Bathing Cattle	672.81	194.74	97.09	91.98
Total Domestic & Cattle water Requirement	396.53	19.16	8.21	6.57
Grand Total	**1069.34**	**213.91**	**105.30**	**98.55**

TABLE 2 (C)

Town/Village	Sikandra-rao	Faridabad	Nagla Jalal	Navli
	A	B	C	D
Ground Water	9726.70	114.42	91.68	91.68
Rain Water	17239.95	202.80	162.50	162.50
Ponds	1.65	0.38	0.38	N/A
Canal Water	47304	N/A	N/A	N/A
Total Existing Resources	**74272.30**	**317.70**	**254.56**	**254.56**
Gross Existing water Resources*	**74272.3**	**8385.3+317.7 = 8703.0**	**8385.3+254.6 = 8639.9**	**8385.3+ 254.6 = 8639.9**

TABLE 2 (B)

I Irrigation Requirements for Rabi and Kharif crops				
		Kharif Crop		
	Umrao-pur	Ratiman-pur	Maha-mahi	Rampur
Maize	286.65	18.81	15.12	12.60
Bajra	1574.1	18.81	15.12	12.60
Juar	0.60	31.65	07.56	08.45
Pulses	260.40	03.13	02.52	02.70
Rice	1983.8	81.51	43.68	52.00
Vegetables	360.00	08.36	06.72	06.24
		Rabi Crop		
Wheat	52.36	70.28	97.16	65.80
Gram	02.82	03.77	05.21	03.53
Potato	14.96	20.08	27.26	18.80
Sugarcane	16.83	22.59	31.23	21.15
Vegetables	07.48	10.04	13.88	09.40
Total Irrigation Requirements	**166.45**	**294.94**	**407.16**	**276.14**
II Domestic Water Requirements				
Drinking, washing & Bathing Cattle	125.12	194.74	306.60	273.69
Total Domestic & Cattle water Requirement	9.86	26.28	21.35	24.64
Grand Total	**134.97**	**221.02**	**327.95**	**298.33**

TABLE 2 (D)

Town/Village	Umrao-pur	Ratiman-pur	Maha-mahi	Rampur
	E	F	G	H
Ground Water	102.41	137.80	189.93	128.35
Rain Water	181.52	244.24	336.64	227.50
Ponds	N/A	N/A	N/A	N/A
Canal Water	N/A	N/A	N/A	N/A
Total Existing Resources	**383.93**	**382.03**	**526.56**	**355.85**
Gross Existing water Resources*	**8385.3+383 .9 = 8769.2**	**8385.3+382.03 = 8767.3**	**8385.3+526.6 = 8911.9**	**8385.3+355.9 = 8741.2**

The quality of water within the study area is safe and acceptable for domestic and irrigation requirements except for the pond waters in Sikandra Rao and Faridabad village having alkalinity, chloride, total hardness and TDS at levels of maximum permissible limits in accordance to Bureau of Indian Standards (BIS). Fluoride, arsenic and nitrate tests were conducted on groundwater samples collected from 12 m, 18 m and 30 m depth and results are given in Table 3 (A,B,C). Results indicate that fluoride concentrations at lower depths were slightly above the permissible limits (i.e., > 1.0 mg/l). This can be attributed to the fact that fluoride occurs in the groundwater naturally from the breakdown

or weathering of the bedrocks and soils. However, the permissible limit for fluoride can be extended to 1.5 mg/l for drinking purposes (as per BIS), hence it can be concluded that the fluoride concentrations within the study area lies in the range of permissible limits. Summary of results presented in Table 4, reveals that the existing water resources of Sikandra rao town and adjoining villages are in abundance after fulfilling the major requirements of the people. Although, according to the methodology adopted for determining the groundwater reserves in the present study (*i.e.*, the groundwater reserves for villages has been computed on the basis of groundwater availability per unit area of the entire Hathras district multiplied by the individual village areas), the total existing water resources of the joining villages are scarce and are replenished from the groundwater reserve of Sikandra Rao town. The quality of water within the study area is safe and acceptable for domestic and irrigation requirements except for the pond waters in Sikandra Rao and Faridabad village having alkalinity, chloride, total hardness and TDS at levels of maximum permissible limits in accordance to Bureau of Indian Standards (BIS). Fluoride, arsenic and nitrate tests were conducted on groundwater samples collected from 12 m, 18 m and 30 m depth and results are given in Table 3(A,B,C). Results indicate that fluoride concentrations at lower depths were slightly above the permissible limits (i.e., > 1.0 mg/l). This can be attributed to the fact that fluoride occurs in the groundwater

TABLE 3(A)

	Arsenic (mg/l) MPL 0.01		
Town/Village	Sample 12 m depth	Sample 12 m depth	Sample 12 m depth
Sikandra Rao	0.0070	0.0070	0.0070
Faridabad	0.0050	0.0050	0.0050
Nagla Jalal	0.0056	0.0056	0.0056
Navli	0.0049	0.0049	0.0049
Umraopur	0.0075	0.0075	0.0075
Rampur	0.0068	0.0068	0.0068
Ratimanpur	0.0045	0.0045	0.0045
Mahamahi	0.0050	0.0050	0.0050

TABLE 3(B)

	Nitrate (mg/l) MPL 45		
Town/Village	Sample 12 m depth	Sample 12 m depth	Sample 12m depth
Sikandra Rao	42	42	42
Faridabad	35	35	35
Nagla Jalal	33	33	33
Navli	41	41	41
Umraopur	38	38	38
Rampur	34	34	34
Ratimanpur	33	33	33
Mahamahi	42	42	42

TABLE 3(C)

	Fluoride (mg/l) MPL 1.0		
Town/Village	Sample 12 m depth	Sample 18 m depth	Sample 30m depth
Sikandra rao	0.85	0.90	1.87
Faridabad	0.78	0.95	1.22
Nagla Jalal	0.75	0.87	0.98
Navli	0.8	0.85	1.54
Umraopur	0.75	0.94	1.65
Rampur	0.66	0.91	1.33
Ratimanpur	0.78	0.86	1.15
Mahamahi	0.68	0.81	1.41

TABLE 4

COMPARISON OF WATER AVAILABLE

TO WATER REQUIREMENTS

Town/Village	Quantity of water available from existing water resources (Ha-m)	Quantity of water requirements for different uses (Ha-m)	Water Reserve Status	Water Quality Status	
				Domestic	Irrigation
Sikandra Rao	74272.3	15575.54	w	v (except for pond water)	v (except for pond water)
Faridabad	8703.0	486.71	w	v (except for pond water)	v (except for pond water)
Nagla Jalal	8639.9	280.66	w	v	v
Navli	8639.9	273.16	w	v	v
Umraopur	8769.2	301.42	w	v	v
Ratimanpur	8767.3	515.96	w	v	v
Mahamahi	8911.9	735.11	w	v	v
Rampur	8741.2	574.47	w	v	v

Summary of results presented in Table 4, the existing water resources of Sikandra rao town and adjoining villages are in abundance after fulfilling the major requirements of the. people Although, according to the methodology adopted for determining the groundwater . in the present study (*i.e.*, the groundwater for has been computed on the basis of villages groundwater availability per unit area of the entire Hathras district multiplied by the individua village

areas), the total existing water resources of the joining villages are scarce and are replenished from the groundwater reserve of Sikandra Rao town.

5.0 CONCLUSIONS

following conclusions are being made
Water resources in Sikandra Rao town and adjoining villages are sufficient to fulfill the needs of the people of the region but due to rapid growth in population and changes in the lifestyle of the people, certain strategies like Rain water harvesting, Ground water recharging, Water use education, Efficient irrigation methods, should be adopted for sustainable water management and development of Sikandra Rao town. Use of submersible pumps and jet pumps should be monitored and controlled for proper water water withdrawal to preserve the ground water table level. Ponds are proposed to be constructed in which water can be stored during rainy season and can serve cattle for drinking. withdrawal to preserve the ground water table level. Ponds are proposed to be constructed in which water can be stored during rainy season and can serve cattle for drinking. development of Sikandra Rao town. adopted for sustainable water management and development of Sikandra Rao town.

During monsoon season plenty of water through rain is available which often stands in localities for longer duration causing miseries to the people and health hazard, if this water is detained in ponds, it would not cause flooding of the localities and can simultaneously be used for fisheries which in turn would provide job benefits and business to the people of the village which in tern lead to a sustainable development of the region The irrigation system should be so designed that the quantity of water supplied to the field just fulfils the crop water requirement at the lowest cost and no portion of supplied water is lost or wasted. For domestic purposes also, an effort should be made to use the water just sufficient to fulfill the need. Groundwater should be used according to the requirement and excessive pumping out of groundwater by the public should be avoided. People should be educated for optimal utilization of ground water a region may not get ground water any more. Continuous infiltration of polluted surface water may pollute ground water resource which may hamper the human and aquatic life

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