To Establish Cause Effect Relationship between Flow In Kharicut Canal (Vatva – GIDC) And Groundwater In Its Vicinity Through Modeling

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ABSTRACT
The Kharicut canal was constructed by British officials for irrigation purpose before some 100 years ago. The Kharicut canal is an extension from the Khari River, a tributary of the river Sabarmati. The industries on the bank of canal in Vatva area discharge their partially treated wastewater into the canal. The residents near the canal do not have proper facility for disposal of garbage; they also dump their garbage into the canal. From the data obtained it was known that since June 2011 no water is released from the Narmada canal into the Kharicut canal. So there is accumulation of garbage in the canal. Thus wastewater which now flows through the canal percolates through the wall of the canal and has a possibility of contaminating the ground water. This study features, establishing a relation between contaminants in the Kharicut canal and the ground water. For this purpose computerized models are available which can be used to model the Fate and Transport of contaminants. Spatial flow pattern of contaminants can be found using the Model software and GIS. Samples were collected from various locations i.e., from six locations from the Kharicut canal, four locations from the Sabarmati River and seven different tube-wells (groundwater) every week. The results showed a wide variation in the quality of wastewater from Kharicut canal as the quality and quantity of the wastewater from industries keeps on varying. The quality of the Sabarmati River deteriorates after Narol Bridge as there is discharge of mixture of Sewage and Industrial effluent. The TDS of some samples from Bore-wells were not within permissible limit.

General Terms
Accumulation, computerized models, industrial effluent.

Keywords
Groundwater, Contamination, Fate and Transport, Model, GIS.

1. INTRODUCTION
Water and food are the basic necessity of leaving beings. Water covers the 70% of the earth's surface. Over 70% of our Earth's surface is covered by water. Although water is seemingly abundant, the real issue is the amount of fresh water available:

- 97% of all water on Earth is salt water, leaving only 3% as fresh water.
- 68.7% of that fresh water is frozen in the icecaps of Antarctica and Greenland; most of the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater (30.1%) not accessible to human use, and .3% makes the surface water.
- < 1% of the world's fresh water (~0.007% of all water on earth) is accessible for direct human uses. This is the water found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost. Only this amount is regularly renewed by rain and snowfall, and is therefore available on a sustainable basis. The figure No. 1 shows the graphical distribution of the locations of water on Earth.

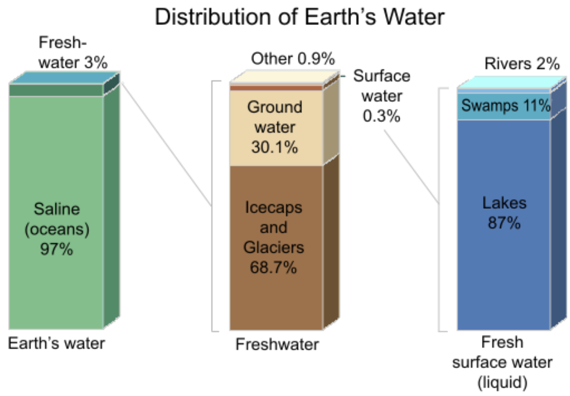

Figure No.1 A graphical distribution of the locations of water on the Earth

Groundwater is one of the fresh water sources which can be used for drinking purpose. Groundwater is that water, which is contained in pores or crevices of various water bearing subsurface rock formations known as aquifer. The amount of water infiltrated and conserved inside the rock formations depend upon the degree of porosity and tortuosity associated with them. Groundwater has historically been considered as reliable and safe source of water protected from surface contamination by geological filters that removes pollutants from water as it is percolated through the soil. Still groundwater is not absolutely free from pollutants. Groundwater mainly contains influx of untreated industrial effluents containing intoxicating metals and chemicals, improper drainage systems, untreated sewage disposal together with widespread discharge to subsurface deposal systems and natural leaching of heavy metals into the soil stratum. Pollution of groundwater is not localized, it moves hundreds of meters away from the source of contamination, both vertically and horizontally in response to gravity, hydraulic pressure and according to Darcy's Law[1].

In Ahmedabad city ground water is the secondary source of drinking water. The industrial units of Vatva area, on the bank of the Kharicut canal, discharge there partially treated effluent into the canal. Door to door collection of garbage is not proper in this area, so people leaving on the bank of the canal discharge their garbage into canal. The issue of unlawful dumping of garbage and chemicals in canal was also raised by the AMC standing committee[2]. The leaching of this polluted water can lead to contamination of the ground water.

The Kharicut canal, 80m long, that begins from Raipur village was constructed more than 100 years ago during the British period for the purpose of providing irrigation support to 10,200 hector in 110 villages that spread over 80 km in Daskroi taluka of Ahmedabad district and Mahemdabad taluka of Kheda district[3]. The Kharicut canal is an extension from the Khari River, a tributary of the river Sabarmati. The canal covers the area like Bapunagar, Naroda, Nikol Road, Odhav, Ghodasar, Vatva and Vastral of Ahmedabad city[2].

The study presented here is to establish cause effect relationship between wastewater flowing in the Kharicut canal and groundwater. The study also includes determining the fate and transport of the contaminant in the groundwater. So this study will be helpful to determine the effect of the wastewater being discharged in canal on groundwater and thus on human-being when such groundwater is used for drinking purpose.

2. STUDY AREA

Ahmedabad is located on two sides of river Sabarmati. It is located from 22°55' to 23°08' North latitude and 72°30' to 72°42' East. Kharicut canal passes through Vatva area of Ahmedabad. Vatva is located at south east direction of Ahmedabad city at Longitude from 220 56'13" North to 220 58'31" North and Latitude from 720 37'11" East to 720 38'46" East, near Ahmedabad – Mahemdabad state highway, covering an area of around 13.5 sq.km. The Vatva Industrial Estate, in Vatva, was established by Gujarat Industrial Development Corporation in the year 1968. The Industrial Estate is divided in to four parts viz. Phase I to Phase IV. The GIDC currently falls under Municipal Corporation Limits .

Figure No.2: Satellite image of Study area

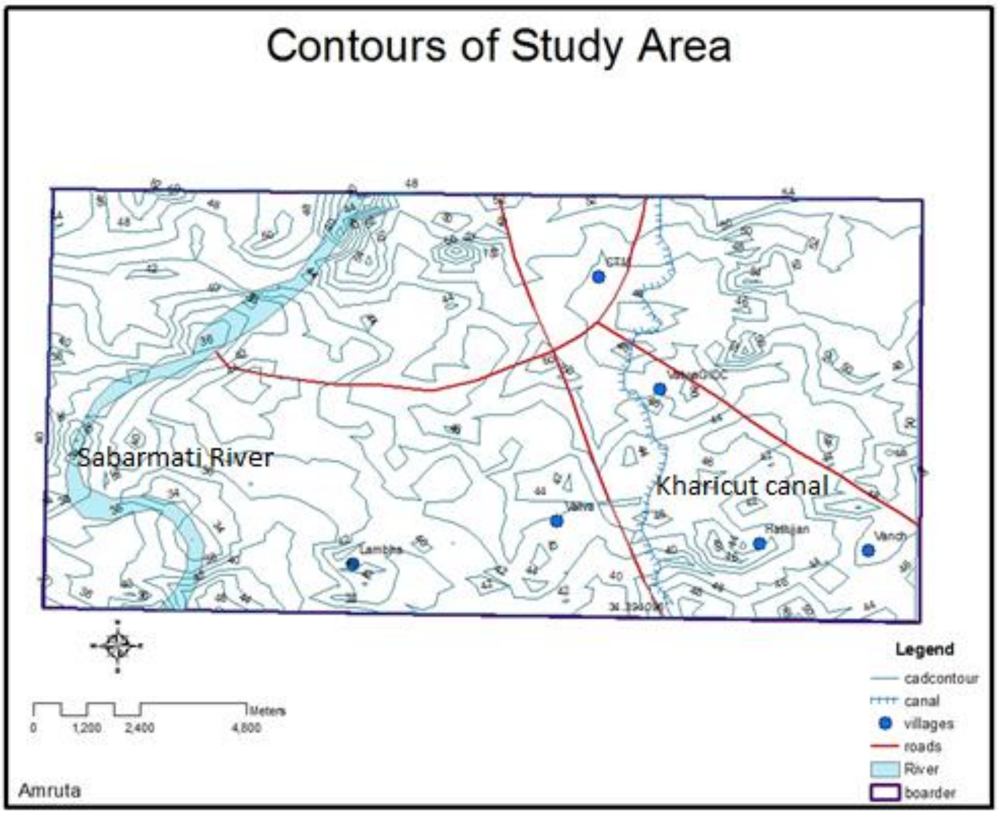

Figure No.3: Contour of study area

The satellite image of the study is also presented in Figure No. 2. The contour of the Ahmedabad area showed that ground water movement is from East towards west. The contour of the study area is as shown in Figure No. 3. This shows that contaminants will be moving from Kharicut canal towards the river Sabarmati after crossing the vast area. The wastewater samples are to be collected from six locations of the Kharicut canal and four locations of the Sabarmati River. Samples of groundwater are to be collected from the tube-wells located in the area which comes in between East i.e. Kharicut canal and West i.e. Sabarmati River.

3.1 MATERIAL & METHODS

GIS software Arc GIS 9.7 and Auto CAD 3D 2012 are used to get the contour of the study area and the direction of flow of water. The contours depict that the flow of water is towards west from the canal. The contour are shown in Figure No.3. So samples of the ground water from the tube wells are to be collected from the area on west of the canal. Sabarmati river is also selected in study area as water flow is on the river side. To Study the fate and transport of the contaminants Visual MODFLOW is to be used [4].

3.1.1 Visual MODFLOW (VMOD) Model

Visual MODFLOW (VMOD) is a graphical interface for MODFLOW [5]. Following are the details of the model:

1) **Flow Properties**: Those physical model properties affecting the groundwater flow simulation. Flow properties include; hydraulic conductivity (Kx, Ky, and Kz), specific storage (Ss), specific yield (Sy), porosity and initial heads. Each of these flow properties must be defined for each cell in the model domain

2) **Transport Properties:** Those physical and chemical model properties affecting the fate, migration and degradation of a contaminant plume in groundwater, or adsorbed to the soil. Transport properties include; dispersion (Dx, Dy and Dz), bulk density, distribution coefficient (Kd), decay constants, initial concentrations.The equation (1) is used in the MODFLOW

$$\frac{\partial}{\partial x}\left[K_{xx}\frac{\partial h}{\partial x}\right] + \frac{\partial}{\partial y}\left[K_{yy}\frac{\partial h}{\partial y}\right] + \frac{\partial}{\partial z}\left[K_{zz}\frac{\partial h}{\partial z}\right] + W = S_s\frac{\partial h}{\partial t} \quad (1)$$

Where,

K_{xx}, K_{yy} and K_{zz} = hydraulic conductivity along the *x, y*, and *z* coordinate axes (L/T)

H = potentiometric head (L)

W = volumetric flux per unit volume representing sources and/or sinks of water, where *negative* values are extraction, and *positive* values are injections (T^{-1})

3.1.2 Sample Collection

For the study purpose the samples are to be collected from Kharicut canal, Sabarmati River and Tube-wells. The Figure No. 2 shows the location of sampling point. Parameters selected to be analyzed are: pH, TDS, COD and Chlorides.

Table No. 1: Details regarding Number of samples to be collected and Frequency of sampling

Location of sampling point	No. of Samples	Frequency of sampling
Kharicut canal	6	7days
Sabarmati River	4	7 days
Tube-wells	7	7 days

3.1.3 Analysis Results

The Samples from Kharicut canal and Sabarmati river were collected and analyzed. The analysis results are shown below in the Table No. 2. And Table No. 3

Table No. 3: Analysis result of the samples from Kharicut canal (All units except pH are in mg/l)

Date	Location	pH	TDS	COD	Cl^-
18/1	(1) *	7.2	2620	373.9	828
	(2) *	7.9	3460	354.24	1640
	(3) *	7.8	3380	393.6	1280
	(4) *	7.4	4880	649.4	3240
	(5) *	7.7	3150	511.68	2120
	(6) *	8.0	3530	669.12	
24/1	(1)	7.2	2880	231.44	800
	(2)	7.0	3650	273.52	1160
	(3)	7.1	3110	315.6	1000
	(4)	7.3	3950	526	1320
	(5)	7.0	3420	511.68	1880
	(6)	7.1	3020	841.6	2040
30/1	(1)	7.3	1930	251.68	999.6
	(2)	7.2	2340	212.96	1232.8
	(3)	7.1	2410	387.2	1499.4
	(4)	7.1	5130	851.84	3998.4
	(5)	7.0	3600	638.88	2499
	(6)	7.0	3750	522.72	2465.6
7/2	(1)	7.2	1886	232.32	800
	(2)	7.1	2160	251.68	1200
	(3)	7.0	2800	445.28	960
	(4)	7.2	2870	600.01	1840
	(5)	7.1	2680	735.68	2320
	(6)	7.0	2800	755.04	3040
14/2	(1)	7.1	444	404.8	480
	(2)	7.0	612	343.2	1200
	(3)	6.8	445	431.2	1400
	(4)	7.2	580	633.6	1600
	(5)	7.2	810	774.4	2120
	(6)	7.1	834	704	2000
21/2	(1)	6.7	740	247	440
	(2)	7.0	1660	316.16	1000

	(3)	6.7	1320	355.68	800
	(4)	6.7	2333	859.56	1400
	(5)	6.3	1354	652.08	800
	(6)	6.8	1465	375.44	880
28/2	(1)	7.5	1020	201.6	600
	(2)	7.0	1565	221.76	1000
	(3)	7.0	1600	524.16	960
	(4)	7.3	4020	766.08	2600
	(5)	7.3	3400	524.16	2200
	(6)	6.7	3025	614.88	1800
*(1) Near Expressway, (2) Near Trikampura, (3)Near Jay Steel and Profile, (4) Near Torrent Power Plant, (5) Near Green CETP, (6) Near TSDF					

Table No.3: Analysis result of the samples from the Sabarmati River (All units except pH are in mg/l)

Date	Location	pH	TDS	COD	Cl^-
17/1	(1) #	7.9	227	96	44
	(2) #	7.8	226	90	24
	(3) #	6.9	1150	211.2	232
	(4) #	6.8	2030	288	452
23/1	(1)	7.8	258	37.6	24
	(2)	7.7	232	37.6	32
	(3)	7.0	1330	263.2	264
	(4)	7.2	2310	169.2	640
30/1	(1)	8	173	38.72	24
	(2)	7.9	162	19.36	24
	(3)	8	784	464.64	300
	(4)	7.4	1250	154.88	833
6/2	(1)	7.6	223	58.08	32
	(2)	7.8	243	67.76	32
	(3)	7.0	943	212.96	160
	(4)	7.2	1780	309.76	480
13/2	(1)	7.3	220	35.2	24
	(2)	7.3	243	35.2	24
	(3)	7.2	1054	105.6	320
	(4)	6.5	1890	264.4	600
20/2	(1)	7.8	220	76.8	16
	(2)	7.9	230	80	16
	(3)	7.0	680	160	48
	(4)	7.0	1080	280	476
27/2	(1)	7.6	280	40	28
	(2)	8.0	220	20	20
	(3)	7.5	840	320	220
	(4)	7.0	1680	320	540
#(1) Ambedkar Bridge , (2) Vasana Barrage, (3) Narol Bridge, (4) Near Kamod Village					

The samples from bore-well were collected in January and February, 2012, and the analysis results are show in the table No. 4.

Table No. 4 Analysis result of the samples from Bore-well

Date	Location	pH	TDS	COD	Cl^-
2/1	(1) Lambha	7.2	1360	19	452
	(2) Vatva-1	7	1150	38	764
	(3) Narol	7.1	814	38	248
7/2	(1) Lambha	7.1	1300	19.3	844
	(2) Vatva-1	7	795	38.72	524
	(3) Narol	7.2	795	29.04	276
14/2	(1) Vatva-1	7.2	656	17.52	380
	(2) Vatva-2	7.4	600	122.6	380
	(3) Vinzol-1	7.2	724	87.6	600
	(4) Vinzol-2	7.2	656	87.6	280
21/2	(1) Vatva-1	6.7	650	19.76	372
	(2) Vatva-2	6.5	645	288	352
	(3) Vinzol-1	7.0	520	96	252
	(4) Vinzol-2	6.8	750	96	452
	(5) Narol	6.7	510	57.6	264
28/2	(1) Vatva-1	7.2	780	20	385
	(2) Vatva-2	7.5	880	40	336
	(3) Vatva-3	7.5	830	50.6	220
	(4) Vinzol-1	7.5	620	20	252
	(5) Vinzol-2	7.3	980	40	480
	(6) Near express-way	7.4	1080	40	448
	(7) Narol	7.1	870	40	240

4. CONCLUSION

The analysis results show that the quality of Kharicut canal varies widely because the quality as well as the quantity of the waste water discharged by the industries varies. The TDS value after Torrent power plant is high as there is discharge made by them during bleed-off. After each sample collection point COD, Chlorides and TDS value increases, in Kharicut canal, as there is addition of effluent by industries before the sample collection point. The water from the bore-well also exceeds the permissible limit of IS-10500 for TDS. pH of all the samples were within the permissible limits.

This study will be helpful to the regulatory authorities to regulate the industries from discharging their waste. The local people will come to know about the quality of water they drink and take steps against industries.

From the present study following results are anticipated:

- Effect of the wastewater on the quality of groundwater
- Concentration of the contaminants, whether they are within permissible limit or not.
- Fate and transport phenomena of the contaminants

5. ACKNOWLEDGMENT

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