JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Study of Soil and Ground Water quality in Pre-Monsoon and Post-Monsoon in 2020 and leaching of heavy metals from soil in the region of Bhachau, Kachchh.Gujarat.

M.D. Nathani a, G.A. Baxi b

a) Women Scientist, Department of Science and Technology, New Delhi. Mail Id madhu.nathani@kskvku.ac.in

b) Dean -Science faculty, HOD,-Department of Chemistry, KSKV Kachchh University, Gujarat. Mail ID – girinbaxi@kskvku.ac.in

Abstract

Assessment of heavy metal and physicochemical pollutants in groundwater was carried out at the key sites in Taluka Bhachau, Kachchh, Gujarat The results of statistical analysis prove the elevated concentrations of some chemical elements leading to pollution along with heavy metals (i.e. Pb, Cu, Zn, Cd, Fe, Cr, Ni and Co) are related to anthropogenic and industrial activities leading to contamination of soil but most of the heavy metals are retained in the soil and does not leach out in groundwater. Only those whose ionic forms are soluble in water percolate along with water to the groundwater and contaminate it but it is substantially variable according to the porosity of areas. The concentration of chloride, calcium and fluoride is found to be increased in the post-monsoon season. All the soil samples in both the consecutive seasons are alkaline and Heavy Metal concentration is found to be decreased because of washing due to rain but not leached to the groundwater levels in the post-monsoon season.

Key Words- Groundwater qualities, physicochemical parameters, Heavy metals, Bhachau, Kachchh

Abbreviations

DL-Desired Limit, PL- Permitted Limit Pb- Lead, Cu- Copper, Zn- Zinc, Cd- Cadmium, Cr- Chromium, Ni- Nickel, Fe- Iron, Co- Cobalt.

Introduction

Industrialization has become an important parameter to measure the development of a country's economy through the establishment of industrial sectors. However, the waste or by-products discharged from them are severely disastrous to the environment consists various kinds of contaminants that contaminate the surface water, groundwater and soil. There are several reasons why the wastes are not safely treated. One of the reasons is mainly due to the lack of highly efficient and economic treatment technology.

The supply of good quality drinking and irrigation water will decrease in the future, as the development of new water supplies will not keep pace with the increasing water needs of industries and municipalities.

Kachchh has become an industrial hub after the severe earthquake on 26th January 2001,

as it was declared a special economic zone for the industrial set up to lure various industrial units to establish and contribute to the development of Kachchh is having a source of Narmada canal but still, that is limited to certain regions and groundwater supplement source is fulfilling the increasing demand of water supply due to the population which has increased in last 19 years after the earthquake. In 20 years Ground Water level depleted to 38 meters is 19 meters per decade.

Population increases with the growth rate of 32% while the water depletion rate is 11.31 % per Decade.

In this study, the groundwater contamination of Bhachau which is mostly used as a portable source in village areas is carried out and it is compared with the recommended standards by the Bureau of Intense Standards (BIS) and suitability of groundwater for irrigation and domestic purpose with the WHO and intense standards. The sample analyzed for the pre-monsoon season reveals that some of the groundwater sources exceed the permissible limit of WHO and intense standards. In this study the basic physicochemical parameters like electrical conductivity, pH, TDS, chlorides, fluorides and heavy metals like sodium, potassium, cobalt, iron, chromium, copper, Zinc are analyzed. Heavy metals in drinking water, irrigation water, and even inhaled can cause severe damage to human health, animals, and plants. not only the industry but the agriculture practices also contribute to the heavy metal concentrations in the soil and inorganic fertilizers contain different levels of heavy metals.

Heavy metals include metals such as lead, cadmium, copper, zinc, chromium and mercury which are major environmental pollutants. Long-term exposure to heavy metals such as cadmium, copper, lead, nickel and zinc can cause deleterious health effects in humans. Long-term exposure to Cadmium causes kidney disease, lung damage, and fragile bones. Lead is a known carcinogen and can also cause high rates of miscarriage, still, births, infertility, permanent damage to the central nervous system, brain, kidneys, cancer and even causes death among others. Long-term consumption of excess zinc may also result in decreased iron and cause anemia. High doses of copper cause anemia, liver damage, kidney dysfunction, stomach and intestinal irritation, neurological complications, hypertension and liver and kidney dysfunctions, lung cancer, pneumonia, heart problems and thyroid damage. Acute exposure to cobalt could cause reproductive and developmental effects. Industrialization has become an important parameter to measure the development of a country's economy through the establishment of industrial sectors. However, the waste or by-products discharged from them are severely disastrous to the environment consists various kinds of contaminants that contaminate the surface water, groundwater and soil. There are several reasons why the wastes are not safely treated. One of the reasons is mainly due to the lack of highly efficient and economic treatment technology.

Work Area

Bhachau is located at 23.29985850 N latitude and 70.34570950 E Longitude. It has an average elevation of 41 meters (134 feet)

Rainfall in Bhachau during 2020 is 446 mm up to 14th August 2020. The average rainfall of the Kachchh district in 2020 is 488 mm.

Bhachau was one of many devastated towns in the Kachchh region of the Indian state of Gujarat, during the 1956 Anjar earthquake as well as in the 2001 Gujarat earthquake. As of 2011, it had a population of 39,532 in over 8,647 households

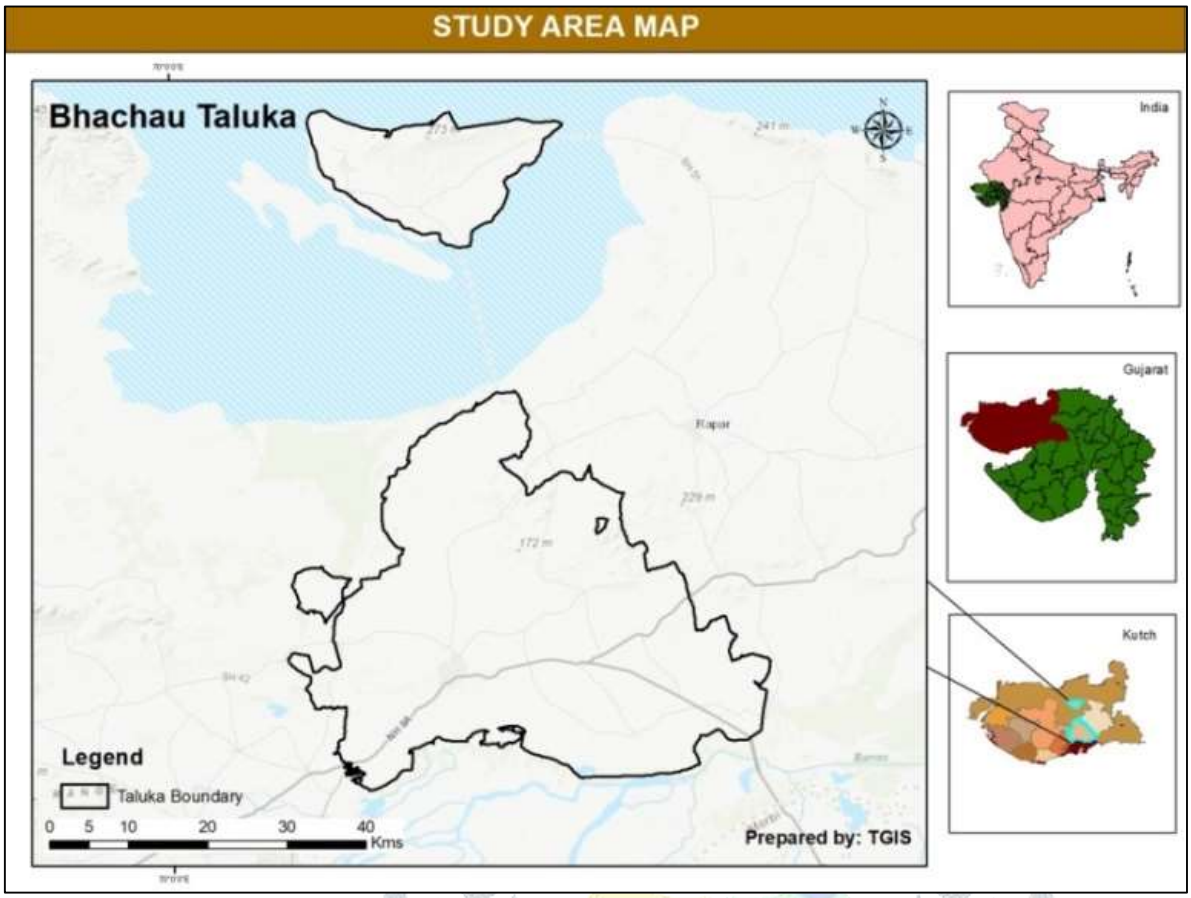
Bhachau Taluka consist of 96 Villages and 69 Panchayats. 25925 Hectare area of Bhachau is benefited by the Narmada canal in 33 villages.

Topsoil is fine-grained dark brown followed by coarse-grained to medium-grained and is porous.

Bhachau is an industrial unit of Kachchh, Gujarat having industries like chemical manufacturing (benzene based), soaps and detergents, timber, plywood, oil refining and mainly salt industries.

In the east Kutch area in Bhachau Taluka 29 industries are registered with the Gujarat pollution control board and running with complete efficiency. Some of the areas have the industries like chemical industries preparing acids, nitrobenzene, Soaps, Detergents, Electronic appliances, edible oil and salt, etc.

Study Area Map



Objectives

- Study of key effluents of the industrial setups.
- To find the various physicochemical parameters including heavy metals in groundwater and soil
- Study of leaching of heavy metal.

Methodology

In the study, the samples were collected from the various villages from Bhachau in pre and post-monsoon season (May 2020 and October 2020) and were analyzed using standard chemicals. The special protocol was maintained for the collection of the samples from the different sources tube well and open wells. Soil samples were collected from the same areas. Soil samples were dried, ground and sieved thoroughly before digesting. Standard methods were used for the analysis of pH, EC; fluorides, etc. suggested by APHA 2012. Metals like sodium and potassium are analyzed using a flame photometer. Iron, Cobalt, Zinc, Chromium, Lead and Copper are analyzed using Atomic Absorption Spectrophotometer. Analysis of Calcium, Magnesium, Chloride, Hardness and Alkalinity is done by titration method.

Result and Discussion

Table -1 Groundwater quality in pre Monsoon, 2020

Ground water quality in pre Monsoon, 2020

Parameter	DL	PL	Max.	Min.	Avg	sample within DL	sample beyond PL
pH			8.32	7.4	7.742 ± 0.076	15	0
TDS	500	2000	1480	192	1015.57±119.84	2	0
Alkalinity	200	600	144	80	125.2±6.06	15	0
Hardness	300	600	830	324	554.46±36.428	5	10
Chloride	250	1000	486.76	177.5	265.42±27.38	6	0
Sulphate	200	400	120.353	3.98	21.08±21.80	15(below DL)	0
Fluoride	1	1.5	0.8	0.4	0.526±0.033	15	0
Calcium	75	200	358	118	232.66±21.80	0	10
Magnesium	30	100	185	464	321.8±23.58	0	15
Potassium	1	4	22.1	1.39	11.08±1.90	0	12
Sodium	200	NA	753.1	90.5	444.21±60.78	2	13
Iron	0.3	1	69.43	3.57	38.43±4.52	0	15
Cobalt	1	5	229.33	1.33	86.47±26.72	2	9
Chromium	0.5	2	161.33	21.33	86.13±11.14	0	15
Zinc	5	15	88.46	68.46	78.93±1.81	0	15
Lead	0.05	NA	3.45	2.18	3.12±0.18	0	15
Copper	0.05	1.5	101.57	0	36.14±7.89	2	13
Nickel	0.02	NA	145.334	12.45	47.3536±43.03	0	15

It is found that physicochemical parameters are between the desired limit (DL) and permitted limit (PL) except Total dissolved salt, but heavy metals are in excess concentration. Range of TDS is 192 ppm to 1480 ppm; 86% samples are within desired and permitted limits. Alkalinity ranges from 80 ppm to 140 ppm, 100 % samples are within desired limits. Hardness in 67 % samples is beyond permitted limits ranging from 324 ppm to 830 ppm.

Metals like chromium range from 21.33 ppm to 161.33 ppm, cobalt ranges from minimum 1.33 ppm to 229.3 ppm which is too high and iron ranging from 3.57 ppm to 69.43 ppm .minimum concentration of Zinc is 68.46 ppm while its maximum concentration is 88.46 ppm .Analysis shows that 100% samples are beyond the permitted limits of Iron, Lead, chromium and Zinc. Cobalt is beyond the permitted limits in 60% samples. Nickel is beyond permitted limits in 100% samples. Nickel ranges from12.45 ppm to 145.33 ppm. Metals found in very high concentration are Mg, Na, Co, Cr, Pb, Fe, Cu, Ni and Zn. Chromium is 10^{th} abundant element naturally occurring in earth's mantle and persists in environment without decomposition. Anthropogenic activities add to the condition where it proves to be toxic to plants and animals and is highly oxidative, corrosive and carcinogenic in nature. Lead is physiologically and neurologically toxic in nature. High concentrations of nickel may cause skin irritation. Lead is a known carcinogen and accumulates in bones as it replaces calcium in bones.

Table -2

Correlation of Physicochemical parameters (Alkalinity, Hardness, Chloride, Fluoride, Calcium, Magnesium)

		Alkalinity	Hardness	Cl	F	Ca	Mg
Alkalinity	Pearson Correlation	1					
	Sig. (2-tailed)						
Hardness	Pearson Correlation	.517*	1				
	Sig. (2-tailed)	0.049					
Cl	Pearson Correlation	-0.074	-0.075	1			
	Sig. (2-tailed)	0.794	0.790				
F	Pearson Correlation	-0.386	-0.365	0.398	1		
	Sig. (2-tailed)	0.155	0.181	0.142			
Ca	Pearson Correlation	0.497	.786**	-0.008	-0.430	1	
	Sig. (2-tailed)	0.059	0.001	0.977	0.110		
Mg	Pearson Correlation	0.339	.820**	-0.109	-0.167	0.290	1
	Sig. (2-tailed)	0.217	0.000	0.699	0.551	0.295	

During correlation study taking alkalinity, hardness, chloride, fluoride, calcium and magnesium as variants with TDS it is found that hardness and alkalinity are correlated while calcium and magnesium are strongly correlated with hardness.

Table 3 – Correlation in Heavy metals (Fe-Iron, Pb-Lead, Co-Cobalt, Cr-Chromium, Zn-Zinc, Cu-Copper, and Ni- Nickel)

Correlations								
		Fe	Pb	Co	Cr	Zn	Cu	Ni
Fe	Pearson Correlation	1						
	Sig. (2-tailed)							
Pb	Pearson Correlation	.490	1					
	Sig. (2-tailed)	.064						
Co	Pearson Correlation	.665**	.381	1				
	Sig. (2-tailed)	.007	.161					
Cr	Pearson Correlation	.037	.046	.172	1			
	Sig. (2-tailed)	.896	.870	.540				
Zn	Pearson Correlation	-.084	-.412	.022	-.093	1		
	Sig. (2-tailed)	.766	.127	.939	.741			
Cu	Pearson Correlation	.508	.217	.661**	-.319	.143	1	

	Sig. (2-tailed)	.053	.437	.007	.246	.610		
Ni	Pearson Correlation	.084	-.261	.095	.119	-.355	.162	1
	Sig. (2-tailed)	.766	.348	.735	.674	.194	.565	
**. Correlation is significant at the 0.01 level (2-tailed).								

For heavy metals correlated taking pH as standard, the study shows Cobalt is strongly correlated with iron and copper.

Table -4 Ground water

Basic Parameters comparative Analysis Pre Monsoon and Post Monsoon

	TDS		pH		Hardness		Calcium		Chloride		Fluoride	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Avg	1015.04	894.93	7.74	7.93	1085.33	946.67	579.10	25.12	54.62	133.22	0.53	0.67
Std dev	463.24	633.65	0.30	0.48	280.05	358.30	210.76	38.19	14.06	92.71	0.13	0.65
Std error	119.70	163.73	0.08	0.12	72.36	92.58	54.46	9.87	3.63	23.96	0.03	0.17
Min	192	142.00	7.4	7.4	600	600	360.70	8.02	39.97	19.98	0.40	0.00
Max	1600	1820.00	8.3	9.1	1600	1600	993.93	160.31	79.93	239.79	0.80	1.50

It found that the average TDS was 1015.04 ppm in Pre-monsoon while it decrease to 894.93 ppm in the post-monsoon with the minimum and maximum concentration of 192 to 1600 ppm and 142 ppm to 1820 ppm in pre and post-monsoon in some of the areas which mean solubility of some of the salts in the water has been shown and leach to the groundwater from the soil. Further, if we consider hardness it is approximately the same in both seasons while the average concentration was 1085.33 ppm in the pre-monsoon and in the post-monsoon It has been diluted and decreased to 946.67ppm. The calcium concentration is also found decreased in the post-monsoon season when compared to the concentration in the pre-monsoon season but the maximum and minimum limit shows vast variations in the pre-monsoon season. The variation range was from 360.70 to 993 ppm while in the post-monsoon season it was just 8ppm to 160ppm. Chloride and fluoride concentration has been found to increase in the post-monsoon season.

Table -5 Heavy Metals in Ground Water (Comparative analysis Pre Monsoon and Post Monsoon)

	Magnesium		Potassium		Sodium		Iron		Lead		Cobalt		Chromium		Zinc		Copper	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Avg	506.23	25.28	11.08	3.74	48.22	355.62	38.43	0.00	0.28	0.00	80.83	0.07	86.13	0.03	78.92	0.00	36.15	0.00
Std dev	310.72	47.03	7.37	2.19	28.13	307.85	17.51	0.00	1.08	0.00	102.02	0.02	43.11	0.01	7.03	0.00	30.55	0.01
Std error	80.14	12.13	1.90	0.56	7.25	79.40	4.52	0.00	0.28	0.00	26.31	0.01	11.12	0.00	1.81	0.00	7.88	0.00
Min	94.94	9.72	1.39	1.80	9.05	7.20	3.57	0.00	0.00	0.00	1.33	0.03	21.33	0.01	68.46	0.00	0.00	0.00
Max	959.14	194.44	22.10	9.00	103.97	827.00	69.43	0.00	4.17	0.00	229.33	0.10	161.33	0.05	88.46	0.00	101.58	0.01

Soil quality in pre and post Monsoon, 2020

Table -6 Basic Parameters

	pH		TDS		Hardness		Calcium		Magnesium		Chloride		Fluoride	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Avg	7.81	7.74	751.13	4060.16	2437.33	4341.33	321.60	231.64	152.93	506.23	398.93	218.48	0.30	0.82
Std Dev	0.29	0.30	1055.96	1852.95	1130.51	1120.19	120.84	84.30	186.73	310.72	468.39	56.25	0.46	0.22
Std error	0.08	0.08	272.72	478.55	291.97	289.31	31.21	21.77	48.23	80.25	120.97	14.53	0.12	0.06
Min	7.20	7.28	104.00	768.00	1200.00	2400.00	160.00	144.28	38.88	94.94	59.95	159.86	0.00	0.50
Max	8.22	8.32	4260.00	6400.00	4960.00	6400.00	560.00	397.57	777.60	959.14	1567.77	319.72	1.50	1.50

Table - 7 Heavy Metals in Soil

	Sodium		Potassium		Lead		Iron		Nickel		Chromium		Cobalt		Zinc	
	Pre	post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Avg	769.1	87.02	46	11.1	1.586	0.278	36.9	10.3	0	0.47	0.01	13.6	0.153	56.5	0.73	16.8
Std Dev	2330	132.6	54.1	7.37	0.992	1.076	4.01	17.5	0	1.22	0.028	9.45	0.055	86.3	0.46	14.1
Std error	601.8	34.25	14	1.9	0.256	0.278	1.04	4.51	0	0.31	0.007	2.44	0.014	22.3	0.12	3.65
Min	32.6	7.52	1.42	1.39	0	0	30.2	0	0	0	0	0	0.09	1.33	0.24	0
Max	9160	408.1	146	22.1	2.263	4.167	44.3	50	0	3.95	0.107	36.2	0.271	229	1.62	46.3

Magnesium concentration has been diluted from 506.23 ppm average concentration in pre-monsoon to just 25.28 ppm while the maximum and minimum concentration found in the pre-monsoon were 94 ppm and 959ppm While in the post-monsoon it has shown a drastic decrease, the minimum concentration 9.72 ppm and the maximum concentration was found in the various samples was 194 ppm. The potassium concentration has also been diluted from the pre to post-monsoon season the average concentration found in the pre-monsoon season was 11.08 while in the post-monsoon season it was 3.74 for the maximum and the minimum limit range for pre-monsoon was 1.39 to 22.10ppm and in the post-monsoon season, it was 1.8 to 9 ppm. The concentration of sodium In the pre and post-monsoon season has been increased as the area is mainly The coastal areas having the dumping of the salt industries in an open area and even there is a concentration of high level of sodium in the air also. it shows an increase from the pre-monsoon to the post-monsoon with the average concentration of 48.22ppm in the pre-monsoon to 355.62ppm in post-monsoon which means The salinity has been increased in the post-monsoon season the range of the sodium in the pre-monsoon was 9ppm to 333.97ppm while it ranges 7.20 to 827ppm in the post-monsoon season. The concentration of iron has been totally diluted in the post-monsoon season which is showing the high average concentration of 38.43 in the pre-monsoon season. The concentration of lead was also found to be totally diluted from 0.28ppm to 0 ppm in the water sample. Cobalt which was very high in the pre-monsoon season that was average concentration found to be 80.83 reduced to 0.07ppm in the post-monsoon. In the pre-monsoon season, the minimum concentration of cobalt was 1.33 ppm and the maximum concentration was 229.33ppm. It has shown a decrease of 1.10 which means if there is a concentration high in the soil then also has not shown leaching to the groundwater levels. Chromium, Copper and Zinc concentrations also show dilution in the post-monsoon season I when compared the analysis of pre and the post-monsoon season is found that most of the samples of the groundwater diluted to the maximum extent but still because of one or another parameter they remained unfit for the human consumption according to the norms of WHO .in the soil analysis the soil is basically alkaline in nature. the average concentration of TDS has been increased in the post-monsoon season while most of the parameters but the calcium, magnesium chlorine concentration has been decreased while the fluorides increased in the post-monsoon season but it was observed that the concentration of all these parameters in Groundwater is

not found to be increased somewhere only the fluoride has been increased, it shows that leaching of only those which are either the positive or negative ions soluble in water has been transferred with percolation of rainwater and polluted groundwater while the metals remain as such in the soil and even in the leaching is to the certain extent in lower layers of the soil but not to the groundwater level. (Table 6 and 7)

Table 8 - Ground Water and Soil quality (Pre- Monsoon and post Monsoon,2020) Bhachau, Kachchh, Gujarat

Parameter	Water		Soil	
	Pre- Monsoon	Post- Monsoon	Pre- Monsoon	Post- Monsoon
TDS	1015.04±119.60	894.93±163.42	751±272.72	4060.10±478.55
pH	7.74±0.08	7.93±0.12	7.81±0.08	7.74±0.08
Hardness	1085.33±72.36	946.67±92.58	2437.33±291.97	434.33±289.33
Calcium	579.10±54.46	25.11±9.87	321.60±31.21	231.64±21.77
Chloride	54.61±3.63	133.21±23.96	398.93±120.97	218.48±14.53
Fluoride	0.53±0.03	0.66±0.17	0.3±0.12	0.82±0.06
Magnesium	506.23±80.23	25.28±12.13	152.93±48.23	506.23±80.25
Potassium	11.08±1.90	3.73±0.56	46.01±13.98	11.08±1.9
sodium	48.22±7.26	355.62±79.40	769.13±601.76	87.02±34.25
Iron	38.43±4.52	0	36.88±1.04	10.28±4.51
Lead	0.28±0.00	0	1.59±0.26	0.28±0.28
Cobalt	80.83±26.34	0.07±0.01	0.15±0.01	50.53±22.29
Chromium	86.13±11.13	0.033±0.002	0.01±0.01	13.64±2.44
Zinc	78.92±1.81	0	0.73±0.12	16.82±3.65
Copper	36.14±7.88	12.01±0.08	0	
Nickel	0	0.008±0.004	0.067±0.05	0.47±.0.31

Table 9- Water classification Based on TDS (Davis and De Wiest)

TDS(mg/L)	Classification	Sample % Pre monsoon	Sample % Post monsoon
<500	Desirable for drinking	13.33	40
500 – 1000	Permissible for drinking	33.33	13.33
1000-3000	useful for irrigation	53.33	46.66
> 3000	Unfit for drinking and Irrigation	0	0

According to Water classification based on TDS 40% samples are suitable for drinking while 13% are permitted in the absence of any other source of water for drinking but the watr quality is suitable for irrigation.

Ground water suitability for Irrigation

$$Na\% = \frac{(Na^+ + K^+) \times 100}{(Ca^{2+} + Mg^{2+} + Na^+ + K^+)}$$

Table 10 - Ground Water Suitability for Irrigation based on Na%

Na%	Suitability for Irrigation	Sample % pre- monsoon	Sample % post monsoon
< 20	Excellent	100	0
20-40	Good	0	13.33
40-60	Permissible	0	13.33
60-80	Doubtful	0	13.33
>80	unsuitable	0	60

Analysing data for the irrigation suitability of groundwater based on the sodium percentage, shows that the sodium percentage which is less than 20 ppm is excellent for irrigation. In Pre monsoon, 100 % of samples were in excellent range while in Post monsoon it was 0. In Post monsoon season unsuitable range that is more than 80 is seen in 60% samples, this concludes that the concentration of Sodium is increasing salinity of water making it unsuitable for irrigation in long. in Post monsoon season the concentration of Na increased from 20.47±8.10 and 48.22±7.26 to 724.47±604.86 and 355.62±79.40 in soil and water samples respectively which shows washing of sodium from nearby salt dumping areas to soil and its leaching to ground water of Bhachau Taluka which is leading producer and supplier of refined salt .

Table 11 - Ground Water Suitability for Irrigation based on SAR

$$\textbf{SAR} = Na^{+}/\sqrt{(Ca^{2+} + Mg^{2+})}\ /2$$

Range	Quality	Irrigation Suitability	Sample % Pre-monsoon	Sample % Post-monsoon
< 10	S1	Low	100	26.66
10 to 18	S2	Medium	0	13.33
18-26	S3	High	0	6.66
>26	S4	Very High	0	53.33

Table-11 shows the suitability based on the SAR, the range less than 10 is considered as low suitability. Samples in pre monsoon were 100% while it is 26.66 % of samples. The range from 10 to 18 SAR is considered as a medium, the high range of irrigations suitability that is 18 to 26 and more than 26 is very high suitability for irrigation. The SAR data shows that in post monsoon season the ground water is very much suitable for irrigation.

Table - 12 Ground Water Suitability for Irrigation based on Kellies Ratio

KR = $Na^{+} / (Ca^{2+}+Mg^{2+})$

Range	Irrigation Suitability	Sample % Pre- monsoon	Sample % Post- monsoon
< 1	Safe	100	26.66
>1	Unsafe	0	73.33

According to the Kellies ratio, the suitability for the irrigation if the ratio is less than one it is safe, and if it is more than one it is unsafe. In Pre-Monsoon the safe sample percentage was 100 % in Post- Monsoon it decreases to 40 % The unsafe samples % was 0 % while in Post –Monsoon it increased to 60%.(Table- 12)

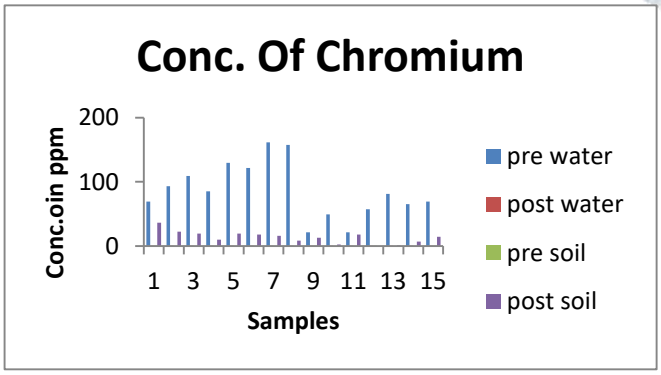
Table – 13 Ground Water Suitability for Irrigation based on MH%

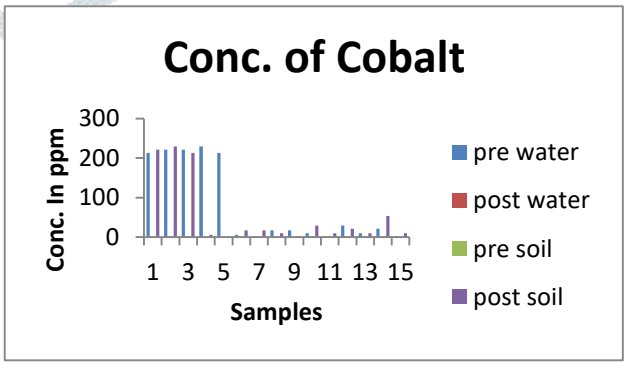
MH% = Mg^{2+}x100/_$Ca^{2+}+Mg^{2+}$

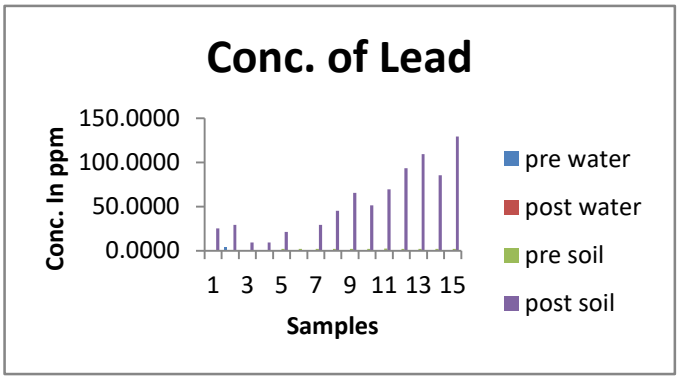
Range	Irrigation Suitability	Sample % pre-monsoon	Sample % post monsoon
< 50	Suitable	100	40
>50	Unsuitable	0	60

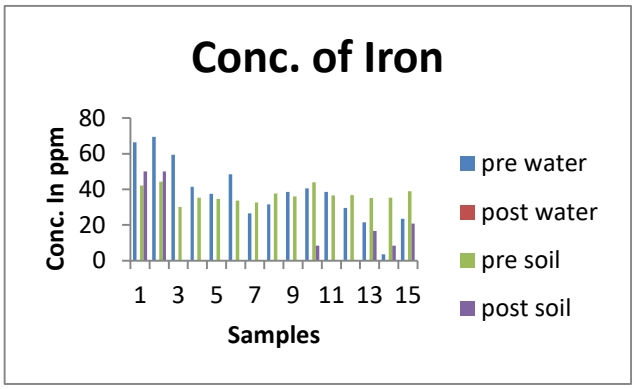
For the groundwater suitability based on MH% (magnesium percentage), less than 50 is considered suitable and more than 50 is considered unsuitable. The samples in Pre-Monsoon were 100% while in Post Monsoon it decreased to 40%. In Pre- Monsoon, the unsuitable samples were 0 % and in Post Monsoon, it is 60 %. (Table- 13)

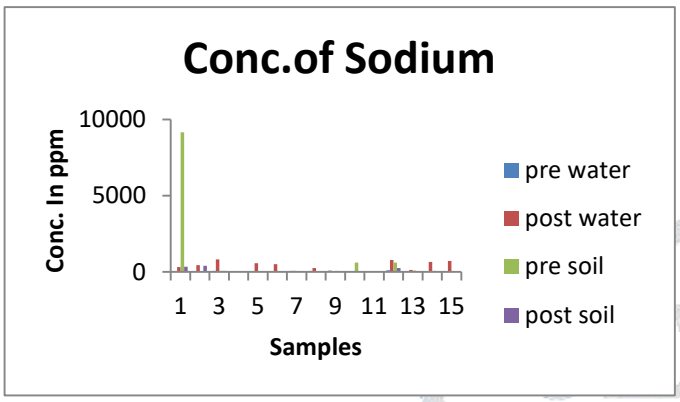
Graphical Representation of Heavy metals in Ground water and soil during pre-monsoon and post monsoon seasons.

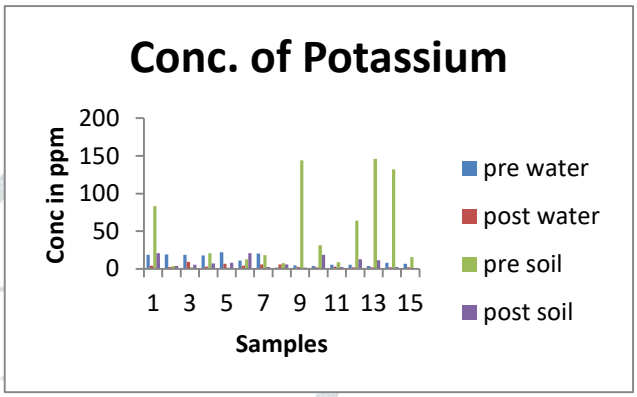


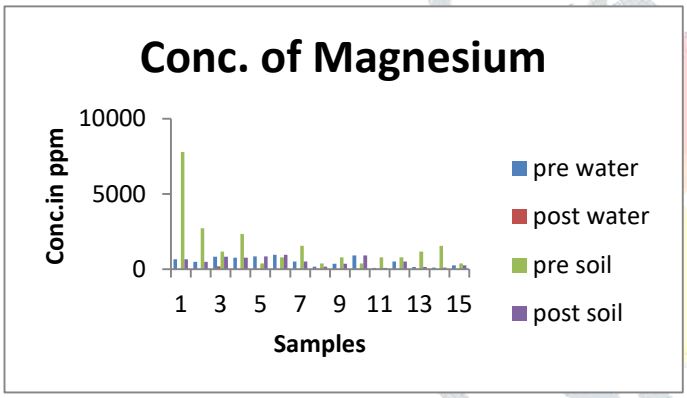


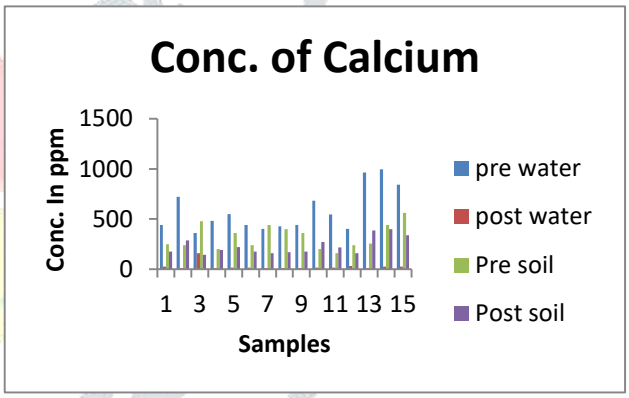

Conc. of Lead
Conc. In ppm
150.0000
100.0000
50.0000
0.0000
1 3 5 7 9 11 13 15
Samples
pre water
post water
pre soil
post soil

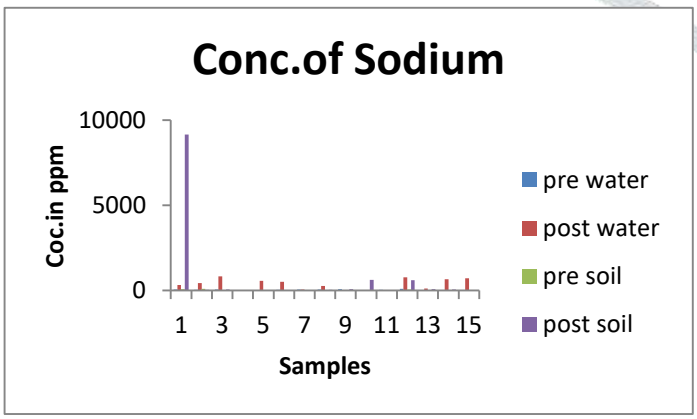

Conc. of Iron
Conc. In ppm
80
60
40
20
0
1 3 5 7 9 11 13 15
Samples
pre water
post water
pre soil
post soil


Conc.of Sodium
Conc. In ppm
10000
5000
0
1 3 5 7 9 11 13 15
Samples
pre water
post water
pre soil
post soil


Conc. of Potassium
Conc in ppm
200
150
100
50
0
1 3 5 7 9 11 13 15
Samples
pre water
post water
pre soil
post soil


Conc. of Magnesium
Conc.in ppm
10000
5000
0
1 3 5 7 9 11 13 15
Samples
pre water
post water
pre soil
post soil


Conc. of Calcium
Conc. In ppm
1500
1000
500
0
1 3 5 7 9 11 13 15
Samples
pre water
post water
Pre soil
Post soil


Conc.of Sodium
Coc.in ppm
10000
5000
0
1 3 5 7 9 11 13 15
Samples
pre water
post water
pre soil
post soil

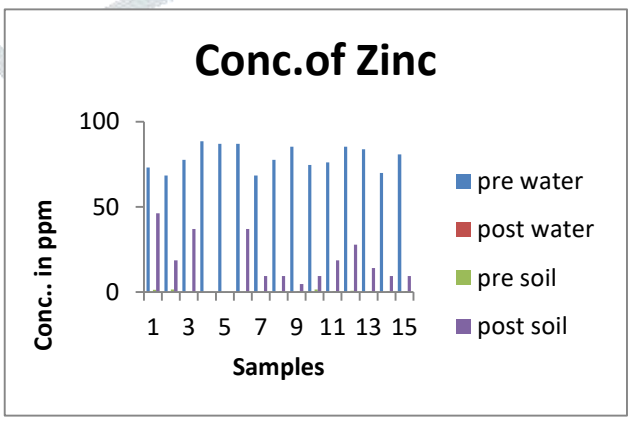

Conc.of Zinc
Conc.. in ppm
100
50
0
1 3 5 7 9 11 13 15
Samples
pre water
post water
pre soil
post soil

Table 14 – Water quality parameters for irrigation

Water Quality Parameter	Targets for Raw [a] Irrigation Source Water [b]
pH	5.8–6.0
Alkalinity	0.75–2.6 meq·L^{-1}
Hardness	<150 mg $CaCO_3$ L^{-1}
Nitrate, Ammonium and Phosphorus	<5 mg·L^{-1} (higher indicates contamination)
Potassium	<10 mg·L^{-1} (higher indicates contamination)
Calcium	<100 mg·L^{-1}
Magnesium	<50 mg·L^{-1}
Sodium	<50 mg·L^{-1}
Sulphate	<100 mg·L^{-1}
Chloride	<100 mg·L^{-1}
Iron	<5 mg·L^{-1}
Boron	<0.5 mg·L^{-1}
Copper	<0.2 mg·L^{-1}
Fluoride	<1 mg·L^{-1}

(Source -Water quality target for raw irrigation water sources.png)

During this study, comparing analysed data with the raw irrigation source water quality

Parameters, it is found that most of the samples are not fit for irrigation also.

Conclusion

In this study it's found that the majority of the heavy metals are in high concentration like lead, chromium, cobalt and iron. Potable must not have these metals above desired limits. analysed parameter are in high concentrations which if used as irrigation water can damage soil quality and also sets in organic phenomenon Narmada water system is accessible within the region of Bhachau in 33 villages directly so drinking water supply mustn't have mixing of groundwater to fulfil the increasing demand with increasing population in this Taluka. Although within the limited supply of Narmada mixing of groundwater is inevitable to fulfil the demand. Groundwater is the most important source of potable water in near future there could be drought or limited supply of Narmada water which is taken into account to be the life line of Kachchh. Thus the threat of quality of groundwater and its recharging will challenge .Concentrations of heavy metals is basically an enormous concern for residents and policy makers. Overexploitation of groundwater sources the matter will worsen if timely proper measures don't seem to be taken.

Soil is irrigated with water which may be a having a high TDS and even in these areas because the soil is extremely saline having high concentration of sodium, the yield reduces when the salt accumulate within the roots and it'll not extract the water from the salty solutions thus leads to the water stress conditions and therefore the growth of the plant is affected.

The heavy metal concentrations within the soil are due to pesticides and inorganic fertilizers contain different levels of the heavy metals and their use by farmer to urge high yield and contribute greatly to the contamination. As we will see from the studies the amount of the

heavy metals within the soil is high but it doesn't leach to the water table shows that the heavy metals aren't within the type of complexes which are soluble in water content The farmers should be made aware to use the various alternative for pesticides and fertilizers like organic fertilizers and the bio pesticides.

Soil is irrigated with water which is a having a high TDS and even in these areas because the soil is highly saline having a higher concentration of sodium, the yield reduces when the salt accumulate in the roots and

it will no longer extract the water from the salty solutions thus results in the water stress conditions and the growth of the plant is affected.

There are various methods to wash heavy metals from the soil and thus prevents leaching of those in groundwater, like isolation by making limestone barriers, chemical treatment using oxidation, reduction and neutralisation, by creating permeable treatment walls which removes contaminants from groundwater by degrading, adsorption processes etc. (Abigail Albright at.el). But the methods are somehow non-economical for the developing country like India. Phytoremediation is that the direct use of green plants to degrade, contain, or render harmless various environmental contaminants, including recalcitrant organic compounds or heavy metals. Plants are especially useful within the process of bioremediation because they prevent erosion and leaching that may spread the toxic substances to surrounding areas. In phytoextraction strategies are termed "hyper accumulators." they're plants that achieve a shoot-to-root metal concentration ratio greater than one. Non - accumulating Metal accumulation species can concentrates heavy metals Cd, Zn, Ni, Pb, Co up to 1000 times than excluder plants path of heavy metals is, contaminates → Rhizodegradation → Phytostabalisation → Phytodegradation → Phytoextraction → phytoaccumulation. Phytoremediation is solely low cost and publically accepted method to cut back metal pollution in soil near the key source of contamination and growing these plants as fencing near industrial sector and fields may reduce the speed of spread of pollutants but this process is time consuming. So to try and do sustainable development in Kachchh nessacery timely steps should be taken by creating awareness to conserve soil thus conserving groundwater quality.

Acknowledgement – Author would like to extend thanks to DST for providing funds for this study, KSKV Kachchh University for support..

References

- Abigail Albright, Sean Dillon- Leaching of metals into groundwater-understanding causes and an evaluation of remedial approach. A Major Qualifying Project Report
- B. V. Tangahu, S. R.S. Abdullah, H. Basri, M. Idris, N. Anuar and M. Mukhlisin", A Review on Heavy Metals (As, Pb, and Hg) Uptake by Plants through Phytoremediation," Hindawi Publishing Corporation International Journal of Chemical Engineering, Volume 2011, 31 pages
- Blue Sheep Fescue: Phytoremediation: A Green Technology to Remove Environmental Pollutants, , *American Journal of Climate Change* (2013) p. 71 – 86
- Ground Water Supply Board, Regional office – Bhuj, Kachchh, Gujarat.
- H. N. Tiwari."GWYB WCR – Bhachau" Ground water year book , regional office data center , central ground water Board , West Central Region, Ahmedabad.
- I V Galitskayaa, Rama Mohan K., Keshav Krishna A, G.I. Batrak, O.N. Eremina , V. S. Putilina , T I Yuganova - Assessment of soil and groundwater contamination by heavy metals and metalloids in Russian and Indian megacities" *Procedia Earth and Planetary Science* 17 (2017) 674 – 677
- Index of Surface Water Bodies of Gujarat, India (1997) , Environmental Geology, 32(1): 5663
- J.Singh, A. S. Kalamdhad," Effects of Heavy Metals on Soil, Plants, Human Health and Aquatic Life*" Int. J. Res. Chem. Environ*. Vol. 1 Issue 2 Oct. 2, 011(15-21)
- Lenntech (2011d). Cadmium (Cd) - Chemical properties, health and environmental effects. Retrieved 9/17/2011 from http://www.lenntech.com/periodic/elements/cd.htm
- Lenntech (2011e). Iron (Fe) - chemical properties, health and environmental effects. Retrieved 9/6/2011 from http://www.lenntech.com/periodic/elements/fe.htm

- Lenntech (2011f). Lead (Pb) - Chemical properties, health and environmental effects. Retrieved 9/17/2011 from http://www.lenntech.com/periodic/elements/pb.htm
- Lenntech (2011g). Manganese (Mn) –Chemical properties, health and environmental effects. Retrieved 9/17/2011 from http://www.lenntech.com/periodic/elements/mn.htm .
- Liu, S.; Zhang, Y.; Bi, S.; Zhang, X.; Li, X.; Lin, M.; Hu, G. Heavy metals distribution and environmental quality assessment for sediments off the southern coast of the Shandong Peninsula, China. Mar. Pollut. Bull. 2015, 100, 483–488
- M lambart , B A leven and RM Green "New methods of cleaning up in soil and water "published by the Hazardous Substance Research Centres as part of their Technical Outreach Services for Communities (TOSC) *program series of Environmental Science and Technology* Briefs for citizens
- Regional office, Gujarat Pollution Control Board, Gandhidaham.
- Source website - GIDC estate, Gujarat industrial development corporation , Gujarat.
- Teresa Akenga1 , Vincent Sudoi2 , Walter Machuka3 , Emmy Kerich- Heavy Metal Concentrations in Agricultural Farms in Homa Hills Homa Bay County, Kenya- International Journal of Science and Research (IJSR) Volume 5 Issue 10, October 2016/1614-1669
- Water quality target for raw irrigation water sources.png
- WHO - International Standards for drinking water WHO, Geneva.1994.
- WHO (1992) Cadmium. Geneva, World Health Organization (Environmental Health Criteria 134).
- WHO (1993) - Guidelines for drinking water quality, World Health organization, Geneva, Vol.1, (1993).
- WHO (1996) -Iron in drinking water. Guidelines for drinking-water quality,2nd ed. Vol. 2.
- WHO (2002) - Standards and Health: Assessment of Risk and Risk Management for water related infectious diseases , World Health Organisation Geneva. WHO (2002):
- WHO (2003) - Guidelines for drinking water quality. Background document for preparation of WHO guidelines for drinking water quality. Geneva, World Health Organization.
- WHO- Guidelines for drinking water quality, World Health organization, Geneva,(2) (1999). Fluoride in drinking water.
- www.cpcb.nic.in – Status of Ground water quality in India – Part I (February 2007), Central pollution control board (Ministry of environment and forests)