Evaluation of Water Quality Index for Ground Water of Residential Area of Surat City, Gujarat, India

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Abstract

The physicochemical analysis of 09 ground water samples namely Katargam, Ghoddod road, Sarthana, L.P. Savani road, Sumul dairy road, SCET [Sarvajanik College of Engineering & Technology, Athwalines], Ram nagar, Vadifalia and Ghoddod road SMC water were done by using APHA standard methods of analysis. The results of the analysis when compared with desirable limits of Indian standards for Drinking Water (IS: 10500.1993/2012), in all the 09 sampling stations, most of the selected water quality parameters were observed above desirable limit. The WQI values were found in the range of 124.6-402.7 in winter season, 144.04-424.18 in summer season, 117.82-392.73 in post monsoon season. Based on average value of WQI, lowest WQI was found in Ground water sample of SCET (128.82) and highest WQI was found in ground water sample of L.P. Savani road (406.43). This station is located exactly in opposite direction of Municiple solid waste transfer station. The leachate generated by Municiple solid waste has been percolated down into the ground water may be the reason for higher amount of pollutants present in ground water sample of L.P. Savani road. All 09 ground water samples of residential area were having high WQI values, from these results, it is concluded that none of the studied 09 sources can be used for drinking, domestic or for industrial purposes.

Key Words

Physicochemical, Drinking Water, Desirable Limit, Indian Standards, WQI.

I. INTRODUCTION

Water is one of the most important compounds to the ecosystem. Better quality of water is described by its physical, chemical and biological characteristics. Due to the increased human population, industrialization, use of fertilizers in agriculture and man-made activity the water is being polluted. The natural aquatic resources are causing heavy and varied pollution in aquatic environment leading to depletion of water quality and aquatic biota. [1] The main sources of water for drinking purpose in cities are surface water (mainly the river water) and the ground water. In case of Surat city, Tapi river water is used for drinking purpose, treated water is provided to people by SuratMuniciple Corporation (SMC) after treating the river water in water treatment plant before consumption. But due to rapid industrialization and urbanization, many areas of Surat city are not able to get good quality of drinking water which is provided by SMC. In this case ground water is best alternative. But due to industrial activities, agricultural activities and improper waste disposal, ground water in many areas is being polluted. So, the deterioration in the groundwater quality due to natural and anthropogenic activities has drawn great attention as it is the major alternate source of domestic and drinking water supply. Therefore, it becomes imperative to monitor the quality of groundwater regularly and to device ways and means to protect it. Water quality index (WQI) isone of the most effective tool to evaluate quality of ground water. In context of the above scenario, the objective of the present study was to analyze the selected water quality parameters of the groundwater in the residential area of Surat City, Gujarat, India to check the suitability mainly for drinking and domestic purposes by WQI value assessment.

II. ANALYSIS OF WATER QUALITY PARAMETERS

Sampling and Methodology: Sampling has been done from different zones of Surat City and the name of sampling stations are Katargam, Ghoddod road, Sarthana, L.P. Savani road, Sumul dairy road, SCET [Sarvajanik College of Engineering & Technology, Athwalines], Ram nagar, Vadifalia and Ghoddod road SMC water. Here SMC water has been taken for water quality checking and to compare the ground water quality and quality of treated water which is provided by SMC. Sampling of SMC water

was done from GhodDod Road area. As here samples were bore-well water, the pumps had to be run long enough (15 min) to draw fresh groundwater into the system and from the depth of 35-40 feet samples were collected. The samples were collected in clean polythene bottles without any air bubbles. Before collection, containers were rinsed several times with tap water which were then washed with distilled water. Then acid washing was given to each container with 1:1 HCl. Chromic acid was used to remove organic deposits from containers then again all containers were rinsed thoroughly with ammonia free distilled water. [2] Sampling has been done for three times that is in winter, summer and post monsoon seasons to check the suitability of ground water for drinking purpose. Each season consists of 4 months. 4 times sampling from the same source point was done and each analysis was done for 3-4 times to get concordant reading. In each season more or less the value of parameter was obtained similar. Here constant value is shown for each season.The parameters were analyzed as per the Standard methods for the examination of water and wastewater, 21st Edition. [3] Following parameters were determined by titrimetric method. Total Hardness, Ca and Mg Hardness, Copper and Zinc - EDTA complexometric, Chloride- Argentometric, COD - Open reflux.pH - pH metry, (pH Meter: Systronics, 335), EC and Salinity – EC and Salinity meter (HACH make Sension 5), Turbidity - Turbidimetry, (Turbiditimeter: HACH make, 2100 P), TSS and TDS - Gravimetric (Drying) method, Sodium and Potassium - Flame photometric method (Flame Photo Meter: Systronics, 130). Following parameters were determined by spectrophotometric method. (Spectrophotometer: Systronics, 104), Nitrite - Diazotization, Ammonia - Phenate, Silica - Heteropoly blue, Iron - Phenanthroline , Phenol –Chloroform extraction, Chromium - Diphenylcarbazide , Boron - Carmine, Phosphate - Vanado-molybdo and Fluoride - SPANDS.

III. RESULT OF WATER QUALITY PARAMETERS

The results of analysis for selected parameters were compared with standard for drinking water, given by Indian standards [4], is shown in Table I.

Table: I Comparison of Results of Different Parameters of 09 Sampling Stations of Residential Area with Indian Standard Specification for Drinking Water (IS: 10500), 1993

Water quality Parameter	Desirable Limit (mg/L)	Year 2012	Katargam	Sumul dairy road	Ramnagar	SCET	Vadifalia	GhodDod road	Sarthana	SMC treated water
pH	**7.5-8.5**	winter	**8.06**	**7.34**	**8.25**	**7.8**	**7.6**	**7.68**	**7.53**	**7.57**
		summer	**8.07**	**7.4**	**8.3**	**7.84**	**7.7**	**7.7**	**7.6**	**7.6**
		post monsoon	**8.05**	**7.3**	**8.1**	**7.79**	**7.58**	**7.5**	**7.49**	**7.48**
DO	**7**	winter	**4.2**	**4.3**	**4.1**	6.4	**5.5**	**7.4**	**5.2**	**7.6**
		summer	**4**	**3.9**	**4.05**	**6.3**	**5.4**	**7.3**	**5**	**7.4**
		post monsoon	**4.3**	**4.1**	**4.1**	**6.39**	**5.5**	**7.5**	**5.05**	**7.5**
COD	**10**	winter	**180**	**200**	**200**	**80**	**80**	**60**	**280**	**160**
		summer	**186**	**225**	**210**	**90**	**100**	**70**	**290**	**180**
		post monsoon	**179**	**190**	**193**	**75**	**90**	**59**	**279**	**165**
TSS	**100**	winter	**195.93**	**145.99**	**225.96**	**45**	**125**	**87.89**	**325.92**	**54**
		summer	**200**	**148**	**229**	**46**	**128**	**89**	**328**	**60**
		post	**191**	**146**	**225.7**	**42**	**122**	**82**	**320**	**52**

		monsoon								
TDS	**1000**	winter	**825**	**525**	**1300**	**428.52**	**736.92**	**525**	**495**	**325**
		summer	**850**	**550**	**1339**	**430**	**740**	**530**	**525**	**340**
		post monsoon	**820**	**524.95**	**1225**	**425**	**730**	**520**	**490**	**322**
EC (mS/Cm)	**0.75**	winter	**5.2**	**2.4**	**3.5**	**1**	**6.4**	**1.7**	**2.3**	**1.2**
		summer	**5.4**	**2.5**	**3.7**	**1.02**	**6.5**	**1.8**	**2.5**	**1.3**
		post monsoon	**5**	**2.35**	**3.25**	**0.98**	**6.35**	**1.69**	**2.2**	**1.17**
Salinity (% ppt)	**1**	winter	**2.2**	**1.2**	**1.6**	**0.6**	**3.2**	**0.9**	**1.2**	**0.5**
		summer	**2.5**	**1.25**	**1.7**	**0.6**	**3.3**	**0.99**	**1.25**	**0.7**
		post monsoon	**2**	**1.1**	**1.59**	**0.45**	**3.1**	**0.89**	**1.15**	**0.45**
Total Hardness	**300**	winter	**390**	**340**	**290**	**290**	**470**	**330**	**690**	**300**
		summer	**420**	**350**	**295**	**292**	**480**	**350**	**700**	**310**
		post monsoon	**389**	**342**	**289**	**287**	**460**	**320**	**680**	**298**
Ca Hardness	**75**	winter	**140**	**170**	**90**	**220**	**140**	**110**	**270**	**110**
		summer	**150**	**175**	**98**	**222**	**150**	**120**	**280**	**115**
		post monsoon	**135**	**169**	**87**	**218**	**130**	**100**	**260**	**108**
Mg Hardness	**30**	winter	**250**	**170**	**200**	**70**	**330**	**220**	**420**	**190**
		summer	**270**	**175**	**197**	**70**	**330**	**230**	**420**	**195**
		post monsoon	**254**	**173**	**202**	**69**	**330**	**220**	**420**	**190**
Iron	**0.3**	winter	**0.089**	**0.11**	**0.113**	**0.119**	**0.11**	**0.112**	**0.1**	**0.13**
		summer	**0.1**	**0.15**	**0.15**	**0.2**	**0.22**	**0.2**	**0.25**	**0.15**
		post monsoon	**0.088**	**0.2**	**0.12**	**0.09**	**0.09**	**0.1**	**0.095**	**0.11**
Sodium	**200**	winter	**82**	**83**	**86**	**50**	**87**	**49**	**80**	**52**
		summer	**83**	**83**	**89**	**55**	**88**	**49**	**81**	**55**
		post monsoon	**80**	**80**	**86**	**49**	**83**	**48**	**80**	**49**

Potassium	**12**	winter	**30**	**30**	**45**	**10**	**40**	**12**	**40**	**11**
		summer	**32**	**33**	**47**	**10**	**46**	**13**	**41**	**12**
		post monsoon	**29**	**28**	**42**	**7**	**42**	**10**	**40**	**11**
Ammonia	**0.001**	winter	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		summer	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		post monsoon	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Silica	**14**	winter	**98**	**100**	**90**	**80**	**178**	**120**	**160**	**98**
		summer	**100**	**105**	**100**	**90**	**180**	**130**	**180**	**105**
		post monsoon	**95**	**99.91**	**84**	**78**	**177**	**110**	**150**	**98**
Turbidity (NTU)	**5**	winter	**1.3**	**1.2**	**1.4**	**1**	**2.2**	**1.2**	**2.3**	**1**
		summer	**1.4**	**1.25**	**1.5**	**1.1**	**2.3**	**1.3**	**2.45**	**1.1**
		post monsoon	**1.25**	**1.18**	**1.39**	**0.99**	**2.18**	**1.18**	**2.22**	**0.96**
Chloride	**250**	winter	**114.97**	**94.97**	**574.93**	**34.99**	**194.95**	**99.97**	**204.95**	**39.99**
		summer	**120**	**95**	**579**	**37**	**199**	**110**	**205**	**40**
		post monsoon	**112**	**94.8**	**574.7**	**34.89**	**193**	**100**	**203**	**38**
Flouride	**1.2**	winter	**1**	**1**	**1.02**	**1.03**	**1**	**1**	**1.3**	**1.4**
		summer	**1.5**	**1.25**	**1.05**	**1.08**	**1.4**	**1.1**	**1.45**	**1.6**
		post monsoon	**1.2**	**0.99**	**1.01**	**1.02**	**1.2**	**0.9**	**1.28**	**1.38**
Sulphate	**200**	winter	**65**	**66**	**77**	**50**	**75**	**47**	**79**	**48**
		summer	**66**	**66**	**78**	**52**	**78**	**49**	**79**	**49**
		post monsoon	**64**	**63**	**73**	**49**	**76**	**47**	**78**	**48**
Nitrite	**1**	winter	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		summer	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		post monsoon	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
MPN	**0**	winter	**50**	**45**	**20**	**10**	**90**	**14**	**115**	**0**
		summer	**52**	**46**	**21**	**12**	**92**	**15**	**120**	**0**
		post monsoon	**49**	**45**	**20**	**8**	**89**	**13**	**114**	**0**

IV. RESULT AND DISCUSSION

Apart from essential characteristics, all 09 groundwater samples were colorless, had unobjectionable odour and found with slight salty taste. Residual free Chlorine was not found in any sample of groundwater. Apart from desirable characteristics, Boron, Copper, Zinc, Hexavalent Chromium, Phenol and Nitrate were not found in any sample of ground water.

A) pH:

The variation in pH data for 09 sampling stations is shown in fig.1. The range of desirable limit for pH of water prescribed for drinking purpose by IS: 10500 is 6.5-8.5 and the pH of analyzed ground water samples was found within the limit. The pH values in all studied 09 samples were varied from 7.34-8.25 in winter season, 7.4-8.07 in summer season and 7.3-8.05 in post monsoon season indicating the slightly alkaline nature of selected ground water samples. There is no much variation in pH of different wells which indicates the ground water is tapping from aquifers of a single formation for each individual route. [5, 6]

B) Dissolved Oxygen

The variation in DOdata for 09 sampling stations is shown in fig.2 Dissolved oxygen measures the amount of gaseous oxygen dissolved in aqueous solution. Oxygen gets into the water by diffusion from the surrounding air and as a waste product of photosynthesis. In drinking water 7 mg/l of DO should be present minimum. Twelve parts per million (12 mg/L) is the highest amount of oxygen that can be dissolved in water under standard barometric pressures (sea level), 12 mg/L is known as the saturation point. Zero parts per million (0 mg/L) is the lowest amount of Dissolved Oxygen in water. In all ground water samples DO was found at desirable concentration. The DO in all studied 09 samples was found in the range of 3.2-7.6 mg/l in winter season, 3-7.4 mg/l in summer season and 3.18-7.5 mg/l in post monsoon season. Lowest concentration of DO was found in ground water sample of L.P. Savani road (3.2 mg/l, 3.0 mg/l, 3.18 mg/l in winter, summer and post monsoon season, respectively) and highest concentration of DO was found in treated water sample of SMC (7.6 mg/l, 7.4 mg/l, 7.5 mg/l in winter, summer and post monsoon season, respectively).

C) Chemical Oxygen Demand

The variation in COD data for 09 sampling stations is shown in fig.3 and the range of desirable limit for COD of water prescribed for drinking purpose by International standard, USEPA is 10 mg/l, butCOD should not be present in water which is used for drinking purpose. The COD in all studied 09 samples was found in the range of 60-280 mg/l in winter season, 70-300 mg/l in summer season and 59-279 mg/l in post monsoon season. In all ground water samples, COD was found above desirable limit. Lowest concentration was found in ground water sample of GhodDod Road (60 mg/l, 70 mg/l, and 59 mg/l in winter, summer and post monsoon season, respectively) and highest concentration was found in ground water sample of L.P. Savani road (280 mg/l, 300 mg/l, 279 mg/l in winter, summer and post monsoon season, respectively). This is due to the solid waste disposal (solid waste transfer station) activity as this station is located exactly in opposite direction of this solid waste transfer station. The COD is commonly used to indirectly measure the amount of nonbiodegradable organic compounds in water. [7, 8]

D) TSS, TDS, EC and Salinity:

The variation in TSS, TDS, EC and salinity data for 09 sampling stations is shown in fig.4.1, fig. 4.2 fig.4.3, fig.4.4 respectively and the range of desirable limit for TSS, TDS, EC and Salinity of water prescribed for drinking purpose by IS: 10500 are 100 mg/l, 1000 mg/l, 0.75 mS/cm and 0.5-1% ppt respectively. The EC, Salinity and TDS are inter-related. The TSS of all studied 09 samples was found in the range of 45-425 mg/l in winter season, 46-430 mg/l in summer season and 42-414 mg/l in post monsoon season. The TDS of allstudied 09 sampleswas found in the range of 325-1525.89 mg/l inwinter season, 340-1590 in summer season and 322-1500 mg/l in post monsoon season. The EC of all studied 09 samples was found in the range of 1-6.4 mS/cm in winter season, 1.02-6.5 mS/cm in summer season 0.98-6.35 mS/cm in post monsoon season. The Salinity of all studied 09 samples was found in the range of 0.6-3.2 %ppt in winter season, 0.6-3.3 %ppt in summer season 0.45-3.1 %ppt in post monsoon season. Out of 9 sampling stations, in ground water samples of Katargam, Sumul dairy road, Ramnagar, Sarthana, L.P. Savani road, TSS was found above desirable limit. Out of 9 sampling stations, in ground water samples of Ramnagar and L.P. Savani road TDS concentartion was found above desirable limit. Highest concentration of TSS and TDS was found in ground water sample of L.P. Savani road in all season (425 mg/l, 430 mg/l, 414mg/l in winter, summer and post monsoon season respectively in case of TSS and 1525.89 mg/l, 1590 mg/l, 1500 mg/l in winter, summer and post monsoon season, respectively in case of TDS). Lowest TDS was found in sample of SCET (428.52 mg/l, 430 mg/l, 425 mg/l in winter summer and post monsoon season, respectively). Lowest TSS was found in sample of SCET (45 mg/l, 46 mg/l, 42 mg/l in winter summer and post monsoon season, respectively). Out of 9 sampling stations, in all ground water samples EC was found above desirable limit. Out of 09 sampling stations, in ground water samples of Katargam, Sumul dairy road, Ramnagar, Vadifalia, Sarthana, L.P. Savani road

Salinity was found above desirable limit. Highest EC and Salinity were found in ground water sample of Vadifalia (6.4 mS/cm, 6.5 mS/cm, 6.35 mS/cm in winter, summer and post monsoon season, respectively in case of EC and 3.2%ppt., 3.3%ppt., 3.1%ppt. in winter summer and post monsoon season, respectively in case of Salinity). Lowest EC and Salinity were found in ground water sample of SCET College (1 mS/cm, 1.02 mS/cm, 0.98 mS/cm in winter, summer and post monsoon season, respectively in case of EC and 0.6% ppt., 0.6% ppt., 0.45% ppt. in winter, summer and post monsoon season, respectively in case of Salinity). EC is a measure of total salt content in water. [10, 11] It is a determination of levels of inorganic constituents and capacity of a substance to conduct the electric current in water. Most of the salts in water are present in their ionic forms and capable of conducting current and conductivity is a good indicator to assess groundwater quality. Electrical conductivity is also an indication of the concentration of Total Dissolved Solids and major ions in a given water body. The variation in EC and salinity is mainly due to lithologic composition and anthropogenic activities (like solid waste disposal site) prevailing in this region. As it can be seen from the study area having very high Salinity, ground water from such sources is unsuitable for drinking purpose and for any other purposes. Increasing the soluble minerals along flow path, groundwater movement through salt and evaporation are the major causes of Salination in the residential area especially in case of ground water samples of Katargan, Vadifalia and L.P. Savani road. When the concentration of SuspendedSolids is high it may be aesthetically unsatisfactory for bathing.The TDS concentration was found to be above the desirable limit may be due to the leaching of various pollutants into the ground water which can decrease the potability and may cause gastrointestinal irritation in human and may also have laxative effect particularly upon transits. [9, 10]

E) Total Hardness:

The variation in Total Hardness data for 09 sampling stations is shown in fig.5 and the range of desirable limit for Total Hardness of water prescribed for drinking purpose by IS: 10500is 300 mg/l. The Total Hardnessin all studied 09 samples was found in the rangeof 290-1400 mg/l in winter season, 292-1449 mg/l in summer season and 287-1389 mg/l in post monsoon season. Out of 09 sampling stations, in ground water samples of Katargam, Vadifalia, Sarthana and L.P. Savani road Total Hardness was found above desirable limit. Among all the studied stations, lowest Total Hardness was found in SCET ground water sample (290 mg/l, 292 mg/l, 287 mg/l in winter, summer and post monsoon season, respectively) and highest Total Hardness was found in L.P. Savani road Ground water sample (1400 mg/l, 1449 mg/l, 1389 mg/l in winter summer and post monsoon season, respectively). The presence of rocks and minerals under the earth crust from which the water has been percolated and stored in the aquifer and this could be the reason for the higher Hardness in ground water sample of L.P. Savani road. Water Hardness has no known adverse effects; however, some evidence indicates its role in heart diseases and hardness above desirable limit may cause kidney problems and kidney stone formation. Hard water is unsuitable for domestic porpose because hard water can be a nuisance due to the mineral buildup on plumbing fixtures and shows poor soap and detergent performance. [11, 12]

F) Ca and Mg Hardness:

The variation in Calcium and Magnesium Hardness data for 09 sampling stations are shown in fig.6.1 and fig.6.2 and the range of desirable limit for Ca and Mg Hardness of water prescribed for drinking purpose by IS: 10500 is 75 mg/l and 30 mg/l respectively. The Ca Hardness in all studies 09 samples was found in the range of 90-320 mg/l in winter season, 98-350 mg/l in summer season and 87-310 mg/l in post monsoon season. The Mg Hardness in all 09 samples was found in the range of 70-1080 mg/l in winter season, 70-1099 mg/l in summer season and 69-1079 mg/l in post monsoon season. In all the ground water samples Ca Hardness and Mg Hardness were found above desirable limit. Among all 09 studied samples, lowest Ca Hardness was found in Ramnagar Ground water sample (90 mg/l, 98 mg/l, 87 mg/l in winter, summer and post monsoon season, respectively) and highest Ca Hardness was found in L.P. savani road Ground water sample (320 mg/l, 350 mg/l, 310 mg/l in winter summer and post monsoon season, respectively). Among all the studied 09 samples, lowest concentration of Mg Hardness was found in SCET ground water sample (70 mg/l, 70 mg/l, 69 mg/l in winter, summer and post monsoon season, respectively) and highest Mg Hardness was found in L.P. Savani road Ground water sample (1080 mg/l, 1099 mg/l, 1079 mg/l in winter, summer and post monsoon season, respectively). Water Hardness is usually due to the multivalent metal ions, which comes from minerals dissolved in the water. [9] Above the permissible limit Hardness cause stone in gall bladder.

G) Iron:

The variation in Iron data for 09 sampling stations is shown in fig.7 and the range of desirable limit for Iron of water prescribed for drinking purpose by IS: 10500 is 0.3 mg/l. The Iron in all studied 09 samples was found in the range of 0.089-0.13 mg/l in winter season, 0.1-0.25 mg/l summer season and 0.088-0.2 mg/l in post monsoon season. In all the ground water samples Iron concentration was found within desirable limit. Among all studied stations, Iron concentration was found lowest in ground water

sample of Katargam (0.089 mg/l, 0.1 mg/l, 0.088 mg/l in winter, summer and post monsoon season, respectively) and was found highest in ground water samples of Sarthana and L.P. Savani road (Sarthana: 0.1 mg/l, 0.25 mg/l, 0.095 mg/l in winter, summer and post monsoon season, respectively. L.P. Savani road: 0.13 mg/l, 0.15 mg/l, 0.11 mg/l in winter, summer and post monsoon season, respectively). The most common sources of Iron in groundwater are naturally occurring, that is, weathering of Iron bearing minerals and rocks. Iron contained water makes the teeth and nail black and weak and prolonged consumption of drinking water with high concentration of Iron may lead to liver disease called as haermosiderosis. [13, 14]

H) Sodium and Potassium:

The variation in Sodium and Potassium data for 09 sampling stations are shown in fig.8.1 and fig.8.2 and the range of desirable limit for Sodium and Potassium of water prescribed for drinking purpose by IS: 10500 are 75-200 mg/l and 12 mg/l respectively. Sodium in all studied 09 samples was found in the range of 49-90 mg/l in winter season, 49-92 in summer season and 48-90 mg/l in post monsoon season. Potassium in all studied 09 samples was found in the range of 10-48 mg/l in winter season, 10-49 mg/l in summer season and 07-46 mg/l in post monsoon season. In all the samples of ground water Sodium concentration was found within desirable limit in all season. Among all studied stations, Sodium concentration was found lowest in ground water sample of GhodDod Road (49 mg/l, 49 mg/l, 48 mg/l in winter, summer and post monsoon season, respectively) and was found highest in ground water sample of L.P. Savani road. (90 mg/l, 92 mg/l, 90 mg/l in winter, summer and post monsoon season, respectively). Out of 9 sampling stations, in ground water samples of Katargam, Sumul dairy road, Ramnagar, Valifalia, Saethana, L.P. Savani road, Potassium concentration was found above desirable limit. Among all studied stations, lowest concentration of Potassium was found in ground water samples of SCET (10 mg/l, 10, mg/l, 7 mg/l in winter, summer and post monsoon season, respectively) and highest concentration of Potassium was found in ground water samples of L.P.Savani road (48 mg/l, 49, mg/l, 46 mg/l in winter, summer and post monsoon season, respectively). Potassium is the most common mineral and the sources of Potassium in ground water are the orthoclase, feldspar, microcline, leucite, biotite rock. In study area nearly, 80% of the samples exceed the permissible limit. The excess amount of potassium present in the water sample may lead nervous and digestive disorder. [15]

I) Ammonia:

The variation in Ammoniadata for 09 sampling stations is shown in fig. 9 and the range of desirable limit for Ammonia of water prescribed for drinking purpose by IS: 10500 is 0.001 mg/l. In all studied 09 samples (except L.P. Savani road) Ammonia was absent. In L.P. Savani ground water sample, the concentration of ammonia was 7 mg/l, 7.1 mg/l, 7.0 mg/l in winter season, summer season and post monsoon season respectively (which was found above desirable limit) indicates its origin from MSW which was dumped in opposite direction of this ground water sampling station. [7, 16]

J) Silica:

The variation in Silica data for all 09 sampling stations is shown in fig: 10. The Silica concentration in all studied 09 samples was found in the range of 80-200 mg/l in winter season, 90-220 mg/l in summer season and 78-195 mg/l in post monsoon season.In all 09 ground water samples, Silica concentration was found above desirable limit.Among all Studied stations, lowest Silica concentration was found in ground water sample of SCET (80 mg/l, 90 mg/l and 78 mg/l in winter, summer and post monsoon season, respectively) and highest Silicaconcentration wasfound in ground water sample of L.P. Savani road(200mg/l, 220 mg/l and 195 mg/l in winter, summer and post monsoon season, respectively). Silica is mineral commonly found in ground water (10 mg/L), not easily dissolve in water but held in suspension. In all the samples silica is present beyond the desirable limit. Silica is derived from weathering of silicate minerals contained in the bed rocks. [17, 18]

K) Turbidity:

The variation in Turbiditydata for 09 sampling stations is shown in fig.11 and the range of desirable limit for Turbidity of water prescribed for drinking purpose by IS: 10500 is 5 NTU. The Turbidity in all studied 09 samples was found in the range of 1-2.6 NTU in winter season, 1.1-2.9 NTU in summer season and 0.96-2.5 NTU in post monsoon season. In all ground samples, Turbidity was found within desirable limit. Among all 09 studied stations, lowest Turbidity was found in ground water sample of SCET and in treated water of SMC (SCET: 1 NTU, 1.1 NTU and 0.99 NTU in winter, summer and post monsoon season, respectively. SMC: 1 NTU, 1.1 NTU and 0.96 NTU in winter, summer and post monsoon season, respectively). Highest Turbidity was found in ground water sample of L.P. Savani road (2.6 NTU, 2.9 NTU and 2.5 NTU in winter, summer and post monsoon season, respectively).

L) Chloride:

The variation in Chloride data for 09 sampling stations is shown in fig.12 and the range of desirable limit for Chloride of water prescribed for drinking purpose by IS: 10500 is 250 mg/l. The Chloride in all studied 09 samples was found in the range of 34.99-1914.56 mg/l in winter season, 37-2025 mg/l in summer season and 34.89-1889 mg/l in

post monsoon season. Out of 09 sampling station, in ground water samples of Ramnagar andL.P. Savani road, Chloride concentration was found above desirable limit. Among all studied 09 stations, lowest concentration of Chloride was found in SCET ground water sample (34.99 mg/l, 37 mg/l and 34.89 mg/l in winter, summer and post monsoon season, respectively) and highest concentration ofChloride was found in L.P.Savani road ground water sample (1914.56 mg/l, 2025 mg/l and 1889 mg/l in winter, summer and post monsoon season, respectively). The Chloride is an indicative of salt water intrusion which is actively circulating at relatively shallow depths of ground water and may derived from rain or nearer to coastlines. This station is 10-15 km away from the sea. High Chloride concentration in L.P. Savani road ground water sample indicates salt water intrusion is occurring at this place (this station is 10-15 km far away from sea). Chloride imparts a salty taste and some times higher consumption causes the crucial condition for the development of essential hypertension, risk for stroke, left ventricular hypertension, osteoporosis, renal stones and asthma in human beings. [19]

M) Flouride:

The variation in Flouride data for 09 sampling stations is shown in fig.13. and the range of desirable limit for Flouride of water prescribed for drinking purpose by IS: 10500 is 0.6-1.2 mg/l. Fluoride in all studied 09 samples was found in the range of 1-1.42 mg/l in winter 1.1-1.5 mg/l in summer season and 0.9-1.3 mg/l in post monsoon season. Out of 09 sampling stations, in ground water samples of Katargam, SMC GhodDod road, Vadifalia, Sarthana and L.P. Savani road, Flouride concentration was found above desirable limit. Among all the studied stations, lowest concentration of Flouride was found in ground water sample of GhodDod Road (1 mg/l, 1.1 mg/l, 0.9 mg/l in winter, summer and post monsoon season, respectively) and highest concentration of Flouride was found in ground water sample of L.P.Savani road (1.42 mg/l, 1.5 mg/l, 1.3 mg/l in winter, summer and post monsoon season, respectively). One of the main trace elements in groundwater is Fluoride (F-) which generallyoccurs as a natural constituent. Bedrock containing fluoride minerals is generally responsible for high concentration of this ion in groundwater. Fluoride normally accumulates in the bones, teeth and other calcified tissues of the human body. Excess of Fluoride in water causes serious damage to the teeth and bones of the human body, which shows the symptoms of disintegration and decay, diseases called dental fluorosis and skeletal fluorosis (disease include chronic joint pain, similar to the symptoms of arthritis). Fluoridehas also been associated with low IQ and mental retardation in children. [20]

N) Sulphate:

The variation in Sulphatedata for 09 sampling stations is shown in fig.14 and the range of desirable limit for Sulphate of water prescribed for drinking purpose by IS: 10500 is 200 mg/l. The Sulphate in all studied 09 samples was found in the range of 47-80 mg/l in winter season, 49-82 mg/l in summer season and 48-78 mg/l in post monsoon season. In all the 09 samples, Sulphate concentration was found within desirable limit in all season. Among all the 09 studied stations, lowest concentration of Sulphate was found in ground water sample of GhodDod Road (47 mg/l, 49 mg/l, 47 mg/l in winter, summer and post monsoon season, respectively) and highest concentration of Sulphate was found in ground water sample of L.P.Savani road (80 mg/l, 82 mg/l, 78 mg/l in winter, summer and post monsoon season, respectively). It is mainly derived from gypsum on oxidation of pyrites. The Sulphide minerals add the soluble sulphate into the groundwater through oxidation process. [20]

O) Nitrite:

The variation in Nitritedata for 09 sampling stations is shown in fig.15 and the range of desirable limit for Nitrite of water prescribed for drinking purpose by IS: 10500 is 1 mg/l. In all studied 09 samples (except L.P. Savani road) Nitrite was absent. In L.P. Savani road ground water sample, the concentration of Nitrite was 6.3, mg/l,6.32 mg/l, 6.29 mg/l in winter season, summer season and post monsoon season, respectively. Nitrite reacts directly with hemoglobin in human blood to produce methemoglobin, which destroys the ability of blood cells to transport Oxygen. It can also cause methemoglobinemia or “blue baby” disease. [9, 20]

P) Most Probable Number:

The variation in MPN data for 09 sampling stations is shown in fig.16 and the range of desirable limit for MPN of water prescribed for drinking purpose by IS: 10500 is 0. The MPN in all studied 09 samples was found in the range from 10-120 in winter season, 12-130 in summer season and 08-118 in post monsoon season. In all samples, MPN was found above desirable limit. Among all studied stations, lowest number of Coliform bacteria were found in ground water sample of SCET College (10, 12, 8 in winter, summer and post monsoon season respectively) While Coliform bacteria were absent in water sample of SMC. Among all 09 studied stations, highest number of Coliform bacteria was found in ground water sample of L.P. Savani road (120, 130, 118 in winter, summer and post monsoon season, respectively) due to the sewage discharge and dumping of domestic solid waste near this sampling station. Two common waterborne diseases namely Giardiasis and Cryptosporidiosis (the intestinal illness) caused by the infective strain of E-coli-0157:h7 [20]

V. WATER QUALITY INDEX

The Water Quality Index (WQI) gives the overall quality of water based on large number of physico-chemical characteristics of water. The WQI values of all 09 stations have shown in figure:17and table III. All the stations were having high WQI values reflected that all the stations fall in severely polluted zone. The WQI values were found in the range of 124.6-402.7 in winter season, 144.04-424.18 in summer season,117.82-392.73 in post monsoon season. Apart from all the stations, WQI value was found in ground watersample of L.P. Savani (winter season: 402.7, summer season: 424.18,post monsoon season: 392.73) because of high concentration of Chloride, Total Hardness, Ca Hardness, Mg Hardness, Fluoride, TSS, TDS, EC, Salinity, COD, Fluoride, Silica. According to range of WQI (table: II). It has been found that all above listed 09 stations were in severely polluted zone. So none of the above listed groundwater sources can be used for drinking, industrial, domestic or for any other purpose. L.P. Savani road is located exactly in opposite direction of solid waste transfer station. On this site the solid waste especially domestic wasteis simply dumped and is being transferred to the disposal site without doing any segregation and pollutants may leach out into underground water making the water quality deteriorated. So this could be the reason for the worst ground water quality of sampling station located at L.P. Savani road. The research was carried out on leachate characterization, parameters namely COD (27648 mg/l), Ammonical Nitrogen (1680 mg/l), Nitrite (20.4 mg/l), Chloride (1440 mg/l), Flouride (2.5 mg/l), TSS (4850 mg/l), TDS (34872 mg/l) were found above desirable limit in leachate. [21] The research was carried out on leachate characterization, parameters namely COD (17820 mg/l), Ammonical Nitrogen (1028 mg/l), Nitrite (20.4), EC (51.700 mS/cm) were found above desirable limit in leachate.[22] The research was carried out on, effect of formation of leachate on to the ground water quality, parameters namely COD (111.11 mg/l), Total Hardness (400 mg/l), Ca Hardness (240 mg/l), Mg Hardness (160 mg/l), Iron (0.14 mg/l), Ammonical Nitrogen (1.68 mg/l), Chloride (269.8mg/l), TSS (226 mg/l), TDS (560 mg/l) were found above desirable limit in ground water sample of Khajod which is located nearby distance of (2 Km) from disposal site. [23]Seasonally the high WQI values found in summer season than winter and post monsoon season. The higher values of WQI in summer season may be due to the lowering of water table, while the values of WQI inwinter and post monsoon season is comparatively lower due to recharging of bore wells in the rainy season.[24]The leachate can be treated by natural adsorbent. [25]

According to WQI ranges as shown in table II, ranking were given to source of ground water in table III. From these values of WQI, it is reflected that WQI value for L.P. Savani road groundwater was found highest (406.53) among all 09 stations. WQI range > 300 was obtained for Vadifalia(359.73). WQI range between 200- 300 was obtained for ground water samples of Ramnagar,Sarthana, Sumul Dairy Road, Katargam . WQI range between 100-200 was obtained for ground water samples of GhodDod Road, for treated water of SMC and SCET. WQI value for SCET groundwater sample (128.82) was found lower than treated water (157.94).

In this study, sampling was done for treated water sample which is provided by SMC. The WQI value for this is 156.84, 173.85, 143.13 in winter, summer, and post monsoon season, respectively. According to WQI range, treated water is severely polluted water due to the presence of COD, Total Hardness, Ca Hardness, Mg Hardness, Silica and Fluoride which were present above desirable limit in this water sample.The ground water quality of SCET was found better than treated water.Except TDS, Ca Hardness,MPN all the selected water quality parameter in this study were found within desirable limit and lower in ground water sample of SCET than in SMC treated water. SCET ground water sample had COD, EC, Ca Hardness, Silica and MPN above desirable limit but it was found lower than treated water. In this context, ground water quality of SCET premises was found superior than treated water quality and other 07 sampling stations.
Conclusion: The leachate generated by Municiple solid waste has been percolated down into the ground water may be the reason for higher amount of pollutants present in ground water sample of L.P. Savani road. Ground water quality of SCET premises was found superior than treated water quality and other 07 sampling stations. All 09 ground water samples were having high WQI values, from these results, it is concluded that none of the studied 09 sources can be used for drinking, domestic or for industrial purposes.

VI. RECOMMENDATION

The groundwater should be recharged regularly in every monsoon season by rain water harvesting.

ACKNOWLEDGEMENT

We are thankful to TIFAC CORE in Environmental Engineering, SCET, Surat for providing laboratory facilities.

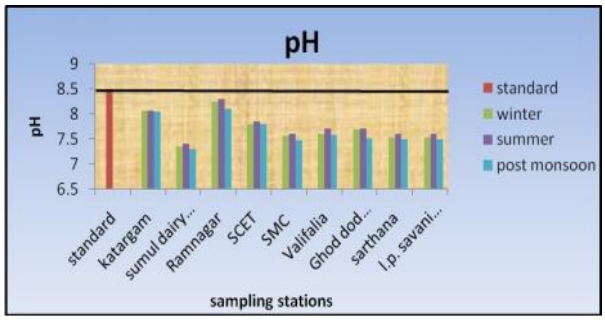


Fig 1: Graphical Representation for pH in Ground Water Samples

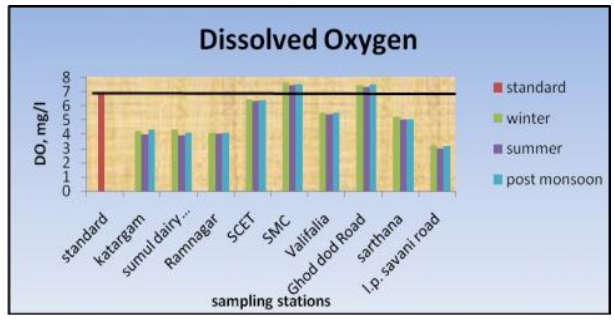


Fig 2: Graphical Representation for Dissolved Oxygen in Ground Water Samples

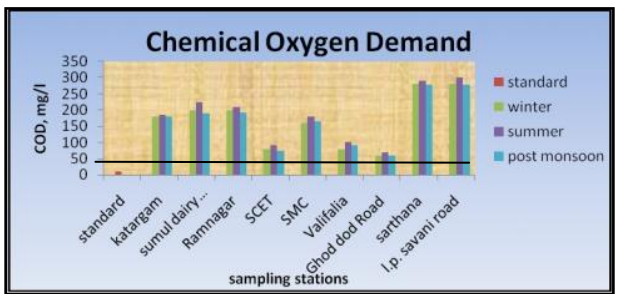


Fig 3: Graphical Representation for Chemical Oxygen Demand in Ground Water Samples

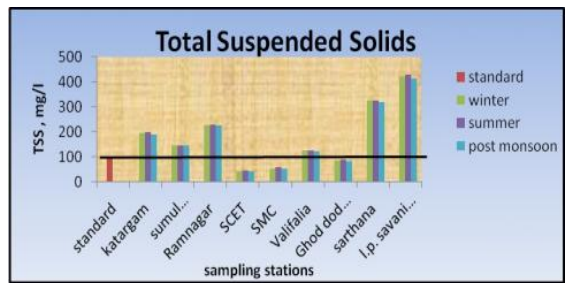


Fig 4.1: Graphical Representation for TSS in Ground Water Samples

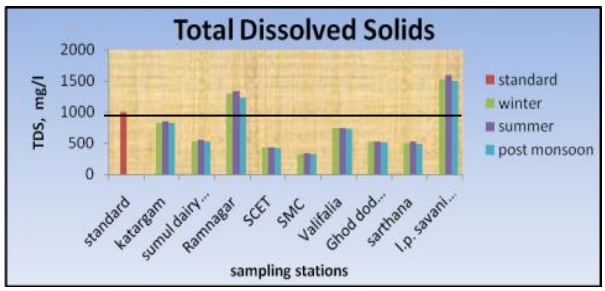


Fig 4.2: Graphical Representation for TDS in Ground Water Samples

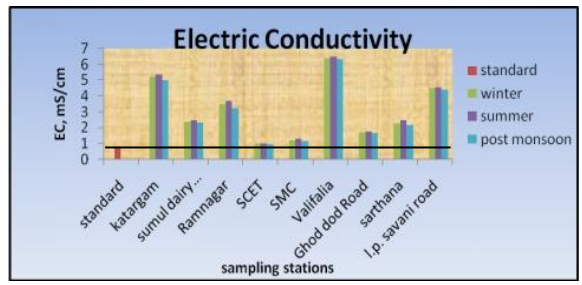


Fig 4.3: Graphical Representation for EC in Ground Water Samples

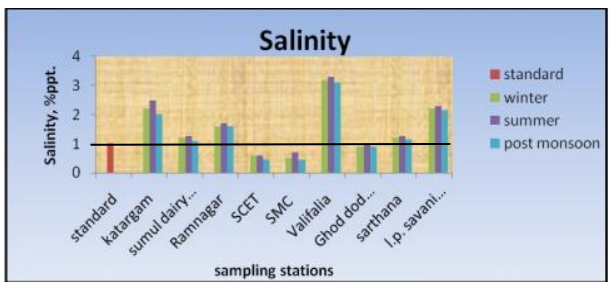


Fig 4.4: Graphical Representation for Salinity in Ground Water Samples

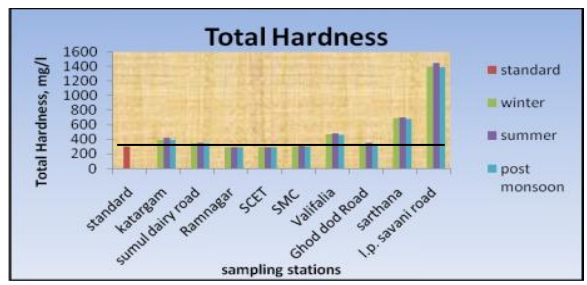


Fig 5: Graphical Representation for Total Hardness in Ground Water Samples

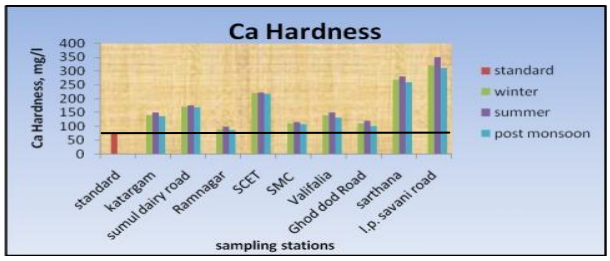


Fig 6.1: Graphical Representation for Ca Hardness in Ground Water Samples

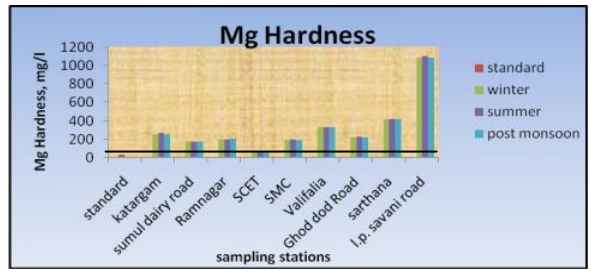


Fig6.2: Graphical Representation for Mg Hardness in Ground Water Samples

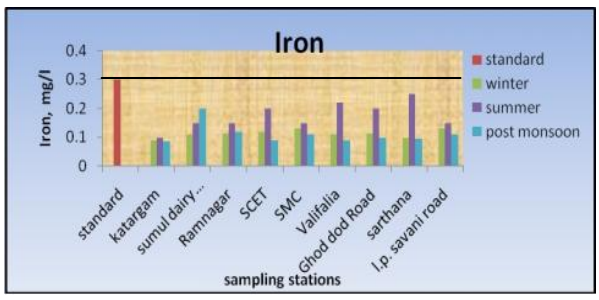


Fig7: Graphical Representation for Iron in Ground Water Samples

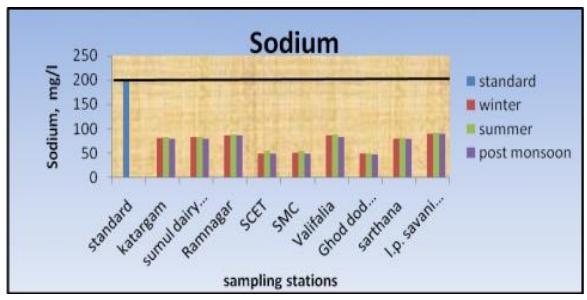


Fig 8.1: Graphical Representation for Sodium in Ground Water Samples

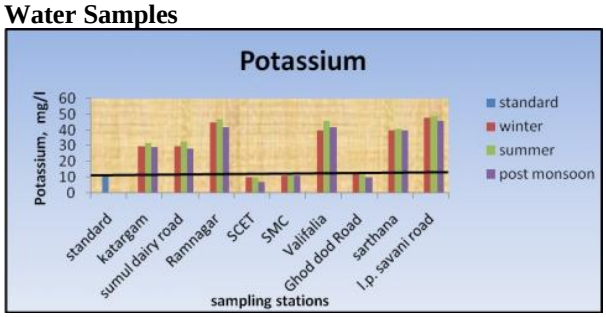
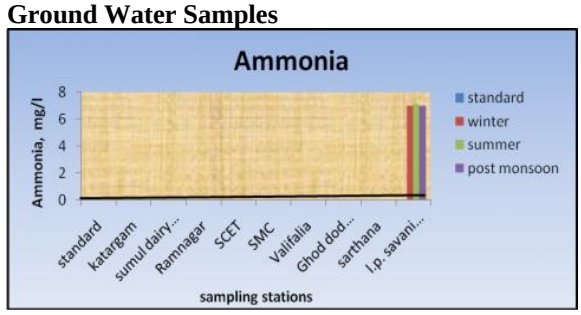


Fig 8.2: Graphical Representation for Potassium in Ground Water Samples



esentation for Ammonia in Ground Water Sample

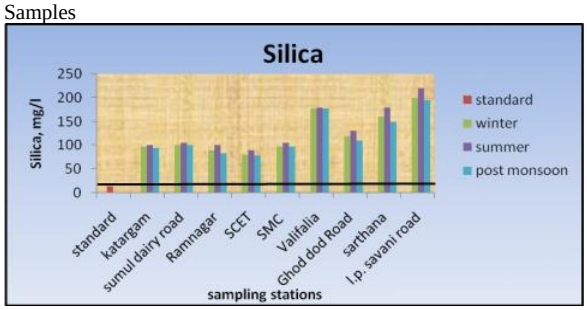


Fig 10: Graphical Representation for Silica in Ground Water Samples

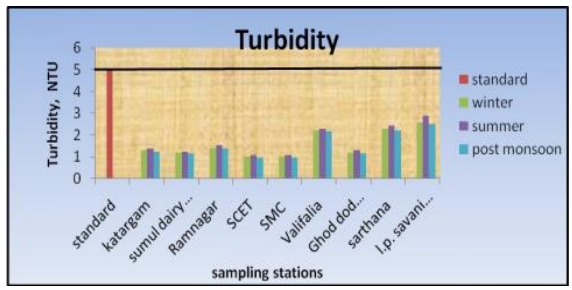


Fig 11: Graphical Representation for Turbidity in Ground Water Samples

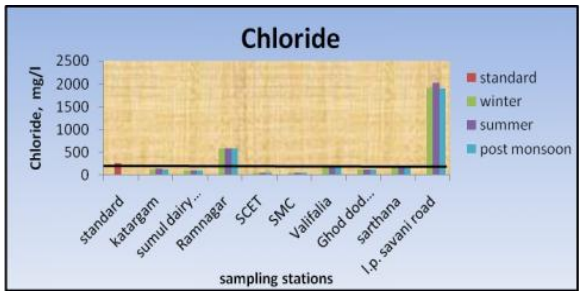


Fig 12 Graphical Representation for Chloride in Ground Water Samples

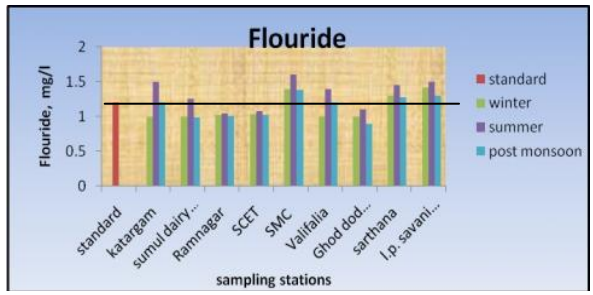


Fig 13 Graphical Representation for Flouride in Ground Water Samples

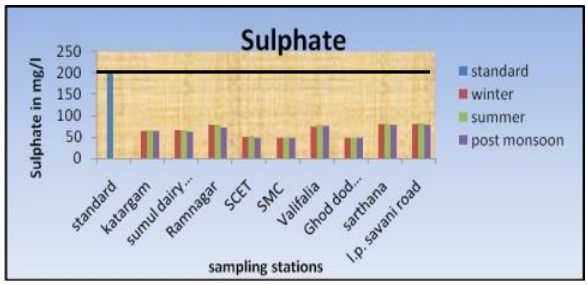


Fig 14: Graphical Representation for Sulphate in Ground Water Samples

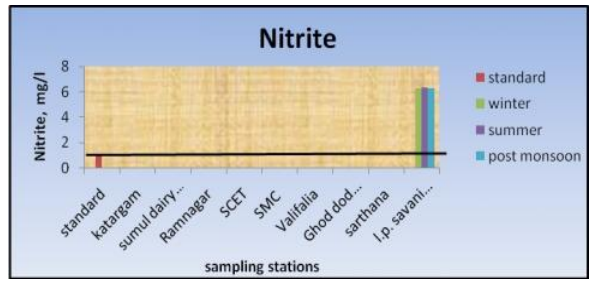


Fig 15: Graphical Representation for Nitrite in Ground Water Samples

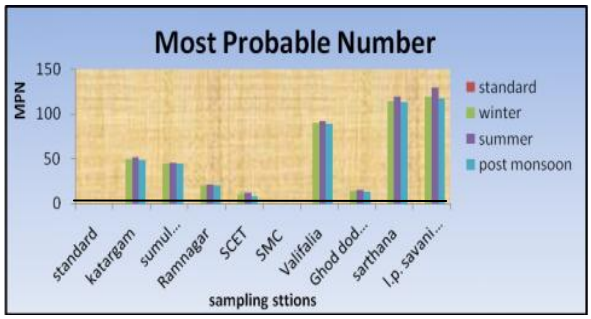


Fig 16: Graphical Representation for MPN in Ground Water Samples

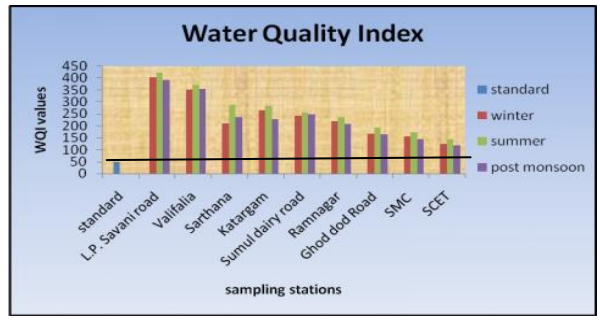


Fig 17 Graphical Representation for WQI of Ground Water Sample

Table II Range of WQI Values

Range	Quality
<50	Fit for human consumption
50-80	Moderately polluted
80-100	Excessively polluted
>100	Severely polluted

Table III: Water Quality Index of Residential Area

Ranking of Sampling stations according to WQI values	Sampling stations	Winter	Summer	Post monsoon	Average
1	SCET	124.6	144.04	117.82	128.82
2	SMC treated water	156.84	173.85	143.13	157.94
3	Ghoddod road	168.6	193.43	163.42	175.15
4	Ramnagar	220.6	237.11	207.96	221.89
5	Sarthana	210.86	289.89	237.08	245.94
6	Sumul dairy road	240.99	257.25	248.45	248.89
7	Katargam	265.38	281.44	227.21	258.01
8	Vadifalia	351.96	372.98	354.25	359.73
9	L.P.Savani road	402.7	424.18	392.73	406.53

REFERENCES

[1] Dahiya S.andKaur A., Physical chemical Characteristics of underground water in Rural areas of Tosham subdivisions, Bhiwani district, Haryana, J. Environ Poll., 6 (4), 281, (1999).

[2] Water Analysis Handbook by HACH, 4th Edition (2003).

[3] Andrew D. Eaton, Lenore S. Clesceri, Eugene W. Rice, Arnold E. Greenberg, Standard methods for the examination of water and wastewater in 21st Ed., (2005).

[4] Beuro of Indian Standard Specification. (IS: 10500)

[5] Reza R. and Singh G., Physico-Chemical Analysis of Ground Water in Angul-Talcher Region of Orissa, India, Marsland Press, Journal of American Scienc , 5(5),53-58, (2009).

[6] Rao C.S., Rao B.S., A.V.L.N.S.H. Hariharan, N. ManjulaBharathi, Determination of Water Quality Index of Some Areas in Guntur District Andhra Pradesh, International Journal of Applied Biology and Pharmaceutical Technology,1(1), 79-86, (2010).

[7] Bundela P.S., Sharma A., Akhilesh Kumar Pandey A.K., PriyankaPandey P. and Abhishek Kumar Awasthi A.K., Physicochemical Analysis of Ground water near Municipal Solid Waste Dumping Site In Jabalpur, International Journal of Plant, Animal and Environmental Science, 2(1), 217-222, (2012)

[8] Ramakrishnaiah C. R., SadashivaiaC.andRanganna G., Assessment of Water Quality Index for the Groundwater in TumkurTaluk, Karnataka State, India (Case study)

[9] Vakharia P. and Desai H.H., Salt water intrusion at coastal region of Surat, (Dissertation), TIFAC- CORE in Environmental Engineering Surat, 2009.

[10] Morrison, G. Fatoki, O.S. and Ekberg, A. Assessment of the Impact of Point Source Pollution from Keikammahoek Sewage Treatment Plant on the Keikamma River-pH, Electrical Conductivity, Oxygen Demanding Substance (COD) and Nutrients, Water. SA., 27, 475-480. (2001).

[11] Reza R. and Singh G., Assessment of Ground Water Quality Status by Using Water Quality Index Method in Orissa, India, World Applied Sciences Journal 9 (12): 1392-1397, (2010).

[12] Osibanjo O. and Majolagbe A.O., Physicochemical Quality Assessment of Groundwater Based on Land Use in Lagos city, Southwest, Nigeria, A.O. Majolagbe et al., Chemistry Journal 2(2), 79-89, 2012.

[13] Yerima, F. A. K. Daura, M. M., and Gambo, B. A., Assessment of Groundwater Quality of Bama Town, Nigeria, J. of Sustainable Development in Agriculture & Environment, 3(2),128-137, 2008.

[14] SujathaA.P. M., Gopalakrishnayya A, Satyanarayana T.,Assessment Of Groundwater Quality In Rural Areas Of Vijayawada, International Journal of Engineering Research and Applications (IJERA), 2(4), 645-648, (2012).

[15] Kaushik A, Kumar K, Kanchan, Taruna, Sharma, Water quality index and suitability assessment of urban ground water of Hisar and Panipat in Haryana. (Case study)

[16] Ramesh. K., Vennila S.,Hydrochemical Analysis and Evaluation of Groundwater Quality in and around Hosur, Krishnagiri District, Tamil Nadu, India, International Journal of Research in Chemistry and Environment, 2 (3),113-122, July 2012.

[17] WHO (World Health Organization) Guideline for drinking water quality, 2nd ed., Health criteria and other supporting information, World Health organization, Geneva, 2, 940-949, (1997).

[18] Olaniya, M.S. and Saxena, K.L., Ground water pollution by open refuse dumps at Jaipur,Indian Journal of Environment and Health, 19, 176-188, (1997).

[19] Akinbile, C.O. and Yusoff M. S., Environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria, International Journal of Environmental Science and Development, 2(1), 81-89, (2011).

[20] Yisa J. and Jimoh T., Analytical Studies on Water Quality Index of River Landzu ,AmericanJournal of Applied Sciences.,7 (4), 453-458, (2010).

[21] Shah. K., Desai H.H., Assessment of Ground water, Textile effluent and Leachate quality of Surat city treated with freshly harvested MoringaOleifera seed powder, Dissertation, TIFAC- CORE in Environmental Engineering Surat, 2012.

[22] Patel I.S, Desai H.H.,Ammonium Removal From Landfill Leachate By Chemical Precipitation,Journal Of Innovative Research And Development, 3(7),116-126,Jul 2014.

[23] Patel D., Study Of Leachate Characteristics And Groundwater Contamination For A Municipal Solid Waste Landfill Site Located At Khajod, TIFAC- CORE in Environmental Engineering Surat, 2011.

[24] Desai H., Aanandwala T. and Desai H. H., Evaluation of Underground Water Quality Of Surat City (India), Journal of Environmental Research and Development, 3 (1), 169-174, (2008).

[25] GamitPayal and Desai Hemangi, A Study On The Effect Of Landfill Leachate- Pollution On Ground Water And Surface Water Quality And Leachate Treatment With Activated Carbon Adsorbent,International Journal of Environmental Research And Development , 11(3), 471-481, January-March 2017.