

Assessment of Ground Water Contamination by Inorganic Impurities in Ferozepur District of Punjab State, India

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Malwa region of Punjab state, India has become the center of water borne diseases due to excessive use of pesticides, chemical fertilizers, heavy metals, industrial toxins that cause toxicity in water. The main contamination in ground water is by physico-chemical parameters and heavy metals *i.e.* pH, total dissolved solids, total alkalinity, total hardness, calcium, chlorides, fluorides, arsenic and lead. The contamination of ground water with heavy metals causes health hazards to humans and animals. Due to lack of adequate facilities and resources for the management and handling of waste, the ground water contamination has been increased. In the present study, assessment of ground water quality was carried out in the villages of Ferozepur district of Punjab state, India. With main emphasis on analyzing the groundwater parameters of Ferozepur district which are responsible for health hazard to humans and animals. Various groundwater samples were collected randomly from the villages of Ferozepur district and analyzed for pH, total dissolved solids, total alkalinity, total hardness, calcium, chlorides, fluorides, heavy metals (arsenic and lead) using standard procedures. The concentrations of calcium, chlorides, fluorides and pH were within the permissible limits, whereas, alkalinity and total hardness were observed beyond permissible limits in most of the water samples. Even among majority of the samples taken, the concentration of arsenic and lead was found within the permissible limits. Results showed that the ground water samples collected from depth ranging from 100 to 360 ft, recorded values within permissible limits for drinking purpose as prescribed by WHO. Further, ANOVA has been applied on analysis results to study the effect of pH on fluoride and chloride, depth on fluoride and chloride and depth on arsenic and lead. Also, to adjudge the overall quality of water in Ferozepur district, the water quality index (WQI) has been calculated on the basis of large number of physico-chemical characteristics of water. The water quality index of ground water in Ferozepur district has been calculated to be 107. The value is close to 100 so the quality of ground water in Ferozepur district can be categorized under 'Good Quality' water.

Keywords: Groundwater, Water quality index, Contamination, Inorganic pollutants.

INTRODUCTION

Water is a primary need for humans and crucial natural resource [1]. There is 70-80 % water in human body. The general survey reveals that 36.1 crore km² surface area is covered by sea out of total surface area of earth *i.e.* 51 crore km². Rivers, lakes and groundwater are the sources of fresh water. The availability of fresh water is getting less day by day in the world [2]. In India, 89 % of groundwater is used for irrigation purpose which is the major source of consumption of groundwater, whereas 9 % is used for domestic purpose and 2 % for industrial purpose [3].

Hydrological monitoring stations are the source of determination of quantity of water by maintaining record of water level, its discharge and velocity and water quality is determined by collecting water samples from points, fixed at these monitoring stations and analysis of various parameters is done. The analysis results revealed the quality of water, on the basis of which spatial and temporal trends of surface water and groundwater are obtained [4].

Groundwater is stored underground in aquifers and is available below the surface in rocks and soil. About 97 % of freshwater is mainly groundwater and is a vital source of drinking water all-over the world. In areas, where surface water supply

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is less and polluted, groundwater is the only source of drinking water [5]. Groundwater at depth is usually safe from microorganisms and chemicals where direct contamination is not possible; whereas at shallow, contamination of groundwater occur by mixing of sewerage, industrial waste and agriculture waste, pesticides, *etc.* [6].

In Punjab state, groundwater is reducing day by day because of its misuse and mishandling and its contamination by geogenic and anthropogenic sources [7]. Contamination of groundwater also occurs due to leaching of fertilizers and manures from agriculture fields. The untreated effluents discharged by industries into sewers/drains may lead to contamination of groundwater as untreated effluents have limits more than permissible limits prescribed by the Government for discharge onto land for plantation/irrigation. The presence of heavy metals in drinking water also causes detrimental impacts on human health if present in higher side than a certain concentration [8].

For maintaining the health of ecosystems, the quality of water is a necessary parameter. The physical, chemical, biological properties and availability of water influence the health of ecosystems. Some ecosystems are sensitive and can be degraded by small changes in the physical and chemical properties of the water [4]. Punjab's ecosystem is drastically affected from contamination of groundwater by various sources like geogenic, agricultural, industrial and urban activities which leads to reduction of groundwater resources and contaminates soil, plants, animals and humans. Keeping in view, all the above aspects, the present study involves the assessment of groundwater quality with respect to inorganic pollutants of Ferozepur district of Punjab state, India.

EXPERIMENTAL

Study area: Firozpur district of Punjab state, India occupies an area of about 5,305 km² in southwestern Punjab (India). Total population of the district is about 10 lakhs, out of which, 5 lakhs are male and 5 lakhs are female. About 95 % rural population depends upon groundwater for execution of daily routine activities like drinking, domestic and agricultural purposes. Global positioning system is used for determining the geographical coordinates of the study area. The coordinates of total study area lie between latitudes of 30°49.218' and 30°57.003' north and longitudes of 74°23.078' and 74°55.638' east (Table-1).

Topography: The state of Punjab has been classified into five agro-climatic zones on the basis of homogeneity, rainfall pattern and distribution, temperature, soil texture and cropping pattern (Fig. 1). Out of the five agro-climatic zones, Ferozepur district fall under western plain zone, which is characterized by arid (dry) and hot zone. Average annual temperature ranges from 25 °C to 26 °C and mean annual rainfall varies from 200 mm to 400 mm. Depth to water level in the area ranges from 1.5 m to 31 m below ground level (mbgl). Water table is at shallow depth at several areas of Ferozepur district where it ranges from 1.5 mbgl to 7.5 mbgl causing water logging at many places. The groundwater is mainly abstracted through hand pumps (up to 25 m) and shallow and medium depth tube wells (upto 175 m) [9].



Fig. 1. Showing five agro climatic zones of Firozpur district of Punjab

Sampling: The primary data regarding extent of various inorganic impurities in the groundwater was collected in the form of questionnaire drafted in the local language for the ease of people. It consisted of questions related to the water source (type, age and bore depth as well as queries about the use of water for drinking and domestic purposes or agricultural purposes). Number of persons surveyed for each source depended on the source of water as well as the medical history of various inorganic impurities in the particular area. By visiting the selected areas of the district, 66 drinking water samples were collected from underground sources where hand pumps, tube wells and submersible pumps were installed. All the samples were stored in identical PET bottles (1 L capacity), marked numerically, and then various parameters were tested namely, pH, TDS, alkalinity, total hardness, and for the content of fluoride, chloride, arsenic, and lead. The analysis results were compared with acceptable limit of WHO for drinking water.

Analysis: Physico-chemical parameters such as pH, TDS, alkalinity, total hardness, fluoride, and chloride concentration were analyzed by using standard methods. pH of solution is determined by using portable handy pH meter, TDS by using TDS meter and fluoride by using field test kits of Merck. The collected samples were also tested for fluoride concentration in water in the laboratory and results were cross-checked by colorimetric determination using SPADNS method, TDS by gravimetric method, total hardness by EDTA titrimetric method, chloride by argentometric titrimetric method, arsenic by atomic absorption spectrometry using hydride vapour generation technique and lead by AAS using graphite furnace assembly (Shimadzu model AA-7000).

TABLE-1 PHYSICO-CHEMICAL CHARACTERISTICS OF GROUNDWATER/ DRINKING WATER

S. B C Constr 1<		0	0									ma/I				
I VI VIA 45 HP 2000 N3749 60F Er44 5519 7.8 980 1.0 456 264 20 66 0.010 0.000 3 VIC 40 HP 2010 N3749 701 E7445519 7.3 77 786 0.3 244 216 245 38 24 216 30 92 0.010 0.0	S. No.	Village ID	Sample ID	Depth (feet)	Source (age)	Latitude	Longitude	pН	TDS	F⁻	Alkalinity	TH	Ca ²⁺	Cl⁻	As ³⁺	Pb ²⁺
2 VIB 35 HP 2010 NNP#9.008 FX15.515 7.1 7.20 0.35 294 216 28 24 66 0.001 0.000 4 VID 45 HP 2013 NNP#9.270 FX445.907 7.3 472 253 256 31.4 28 32 85 0.010 0.010 6 VIF 42 HP 2010 NNP#9.276 FX445.907 7.7 7.6 0.35 410 1.13 0.010 0.	1	V1	V1A	45	HP 2000	N30°49.649'	E74°45.453'	7.8	950	1.10	436	264	30	116	0.010	0.010
3 VIC 40 IP 2010 N30*99.711 57.445.519 7.3 872 0.25 426 158 24 60 0.00 0.00 5 VIL 45 IP 2008 N30*97.26 E7445.512 7.7 7.8 0.43 314 28 32 65 0.010 0.010 7 VIL 40 IP 2006 N3789.724 E7445.546 8.0 100 1.03 4.34 4.6 9.6 0.010 0.010 9 VIL 45 Merro 2000 N3789.724 E7445.546 7.7 7.8 0.05 2.8 2.4 48 2.6 0.01 0.010 10 VIL 255 Merro 2016 N30*97.26 F7445.546 7.7 7.5 6.8 0.03 30 142 28 4.0 0.00 0.00 14 VIL 125 Macro 200 N30*95.75 F7445.547 7.6 7.8 0.02 33 0.02 34	2		V1B	35	HP 2010	N30°49.698'	E74°45.515'	7.7	768	0.35	294	216	28	66	0.010	0.020
4 VID 45 HP 2013 NA9/#9/20 FP 445.007 79 892 0.53 420 254 32 85 0210 0.001 0.001 6 VIF 40 HP 2010 NA9/#9/267 F214/45.87 77 76 0.00 1.00 514 1.24 1.55 1.00 0.000 7 VIF 40 HP 2010 NA9/#9/11 F214/45.87 7.7 812 0.53 560 2.24 41 84 80 0.000 0.000 10 VII 25 Meore 2016 NA9/#9/17 F214/45.87 7.7 7.46 0.35 560 2.25 1.48 2.2 4.8 4.8 0.00 0.010 11 VIX 255 Meore 2016 NA9/#9/36 F214/45.817 7.5 840 0.35 3.14 2.2 7.8 0.00 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 </td <td>3</td> <td></td> <td>V1C</td> <td>40</td> <td>HP 2010</td> <td>N30°49.711'</td> <td>E74°45.519'</td> <td>7.3</td> <td>472</td> <td>0.25</td> <td>236</td> <td>158</td> <td>24</td> <td>46</td> <td>0.010</td> <td>0.010</td>	3		V1C	40	HP 2010	N30°49.711'	E74°45.519'	7.3	472	0.25	236	158	24	46	0.010	0.010
3 VII: 42 HP 2008 NO(39/24) E1/445.12 7.7 7.46 0.43 314 2.88 32 150 0.001 0.001 7 VIII 40 HP 2010 NG793.716 F2145.176 8.1 1160 1.00 51.1 27.8 42 150 0.010 0.010 9 VIII 55 Metro 2000 N80793.718 F2145.167 7.7 7.8 0.035 300 212 34 80 0.001 0.000 11 VIII 55 Metro 2002 N80796.72 F2145.167 7.7 7.8 0.01 1.00 2.6 31.8 2.12 34 4.8 0.010 0.010 0.010 12 VIII 125 HP 1071 N8079.371 F7445.167 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.7	4		V1D	45	HP 2013	N30°49.720'	E74°45.509'	7.9	892	0.55	426	254	30	92	0.010	0.010
0 VII.0 4.0 II.2 4.0 1.0 1.2 4.0 1.0 1.2 1.0 <td>5</td> <td></td> <td>VIE</td> <td>42</td> <td>HP 2008</td> <td>N30°49.726</td> <td>E74°45.512'</td> <td>7.7</td> <td>1000</td> <td>0.45</td> <td>314</td> <td>238</td> <td>32</td> <td>86</td> <td>0.011</td> <td>0.010</td>	5		VIE	42	HP 2008	N30°49.726	E74°45.512'	7.7	1000	0.45	314	238	32	86	0.011	0.010
6 VIII 30 HP 2000 N30P0.722 ET1*85.407 8.0 1100 0.00 120 0.00 124 40 0.00 0.000 0.000 10 VIII 25 HP 1997 N374.97.11 E7445.4807 7.7 744 0.05 360 214 26 74 0.010 0.010 12 VIII 255 Mora 2016 N374.97.457 75 65 0.05 214 26 74 0.010 0.010 13 VIII 125 Mora 2012 N374.97.02 F744.55.167 75 74 0.05 300 142 26 0.010 0	6		VIF	40	HP 2010	N30°49.736	E/4°45.489	8.0 9 1	1090	1.20	458	184	26	130	0.010	0.010
0 VII 85 Macci 2013 Nagria 9171 First 3.57 7.9 812 0.50 308 234 64 0.000 0.000 11 VIII 25 Macci 2016 N3049/745 Lifst 445477 7.5 658 0.25 282 148 26 74 0.010 12 VIII 255 Macci 2016 N3049/745 Lifst 446 80 100 1.0 426 28 14 0.010 0.000 13 VIM 125 HP 2002 N3049/665 F74445.517 7.6 612 0.42 28 87 0.010 0.010 15 VIO 100 HP 2012 N30457.67 F7445.517 7.6 740 0.25 178 192 26 40 0.010 0.010 16 V2D 140 Macci 2002 N3055.507 F7445.517 7.6 340 0.25 228 163 0.601 0.010 0.25 228 164	8		VIG VIH	40 30	HP 2010	N30 49.710 N30°49 724'	E74 43.470 E74°45 460'	0.1 8.0	1120	0.85	470	270 166	42	130	0.010	0.010
0 VII 25 PIP 1997 N39/97/13 F2/4/5.4807 7.7 744 0.36 260 212 34 42 0.000 0.010 12 VIL 255 More 2002 N39/97/62 F2/4/5.647 8.0 100 1.0 426 426 34 82 0.010 0.010 14 VIL 125 H9/02 N39/97/62 F2/4/5.647 8.0 1.00 1.0 1.0 1.0 0.010	9		VIII VII	85	Motor 2013	N30°49.711'	E74°45 457'	7.9	812	0.85	398	234	28 40	98	0.010	0.020
11 VIK 550 Moor 2016 N30*4745 F74*5.477 7.5 658 0.25 282 148 246 44 0.00 0.000 13 VIM 125 HP 2002 N30*49.665 F74*45.517 7.6 642 0.45 318 270 318 280 0.00 0.000 15 VIO 100 HP 2012 N30*49.730 F74*45.517 7.6 642 0.43 318 270 318 220 48 0.010 0.010 16 V2C 120 Moor 2002 N30*5.577 F74*35.5107 7.1 324 0.25 228 48 0.010 0.010 18 V2D 180 Moor 2010 N30*5.500* F74*35.507 7.7 68 0.05 256 53 54 0.40 0.55 250 72 80 0.010 0.010 21 V2D 180 Moor 2011 N30*5.500* F74*35.567 7.6 34 <th< td=""><td>10</td><td></td><td>V1J</td><td>25</td><td>HP 1997</td><td>N30°49.713'</td><td>E74°45.480'</td><td>7.7</td><td>794</td><td>0.35</td><td>360</td><td>212</td><td>34</td><td>82</td><td>0.020</td><td>0.010</td></th<>	10		V1J	25	HP 1997	N30°49.713'	E74°45.480'	7.7	794	0.35	360	212	34	82	0.020	0.010
12 VIL 225 More 2002 N3049762 F74'45.464 80 100 1.00 426 436 38 146 0.000 0.000 14 VIN 110 HP 2012 N3049665 F74'45.490 7.9 826 0.40 300 142 20 78 0.010 0.010 16 V2 V2A 120 More 200 N30'55.167 F74'35.512 7.1 336 0.25 214 248 32 640 0.010 0.010 17 V2B 160 More 2002 N30'55.017 F74'35.857 7.7 642 0.55 326 448 52 88 0.010 0.010 10 V2E 140 More 2011 N30'55.250 F74'35.857 7.8 140 526 423 326 448 52 88 0.010 0.010 0.010 12 V2E 160 More 2011 N30'49.742 F74'23.567 7.8 140 <td< td=""><td>11</td><td></td><td>V1K</td><td>550</td><td>Motor 2016</td><td>N30°49.745'</td><td>E74°45.477'</td><td>7.5</td><td>658</td><td>0.25</td><td>282</td><td>148</td><td>26</td><td>74</td><td>0.012</td><td>0.010</td></td<>	11		V1K	550	Motor 2016	N30°49.745'	E74°45.477'	7.5	658	0.25	282	148	26	74	0.012	0.010
13 VIM 125 HF 2012 N30 49 665 L7445.490 7.6 6.2 6.40 318 270 84 8.2 0.010 0.000 15 VIO 100 HF 2012 N30 49.730 L7445.515 7.6 7.84 0.35 330 124 248 32 66 0.010 0.010 16 V22 120 Motor 2000 N30*55.07 F7.4 376 0.40 234 236 36 64 0.010 0.010 19 V2D 180 Motor 200 N30*55.07 F7.4 376 0.40 234 236 37 248 0.010 0.010 21 V2F 220 Motor 201 N30*55.07 F7.435.167 7.6 354 0.45 250 243 38 0.110 0.03 468 250 48 0.010 0.010 22 V2H 60 Motor 201 N30*55.07 F7.435.167 7.8 100 125	12		V1L	225	Motor 2002	N30°49.762'	E74°45.464'	8.0	1100	1.10	426	426	38	146	0.010	0.010
14 VIN 110 HP 2012 N30*40.685 E74*45.400 7.9 8.26 0.40 300 14.2 20 78 0.010 0.010 16 V2 V2 A1 000 Nore 2010 N30*55.186 F74*35.320 7.1 330 266 33 40 0.010 0.010 17 V28 160 More 2000 N30*55.07 F74*35.857 7.7 642 0.25 228 216 30 64 0.010 0.010 10 V2E 140 More 2011 N30*55.00 F74*35.870 7.7 652 645 452 88 0.010 0.010 12 V2E 140 More 2011 N30*50.52 F74*35.877 7.8 140 453 126 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010	13		V1M	125	HP 2002	N30°49.665'	E74°45.491'	7.6	642	0.45	318	270	34	82	0.010	0.020
15 VIO 100 HP 2012 N30 49730 E74'45.515 7.6 7.84 0.35 330 2 88 7.4 0.000 0.010 17 V2B 160 More 200 N30*55.67 F74'35.120 7.1 324 0.35 17.8 122 26 40 0.010 0.010 19 V2D 180 More 200 N30*55.00 F74'35.931' 7.4 376 0.40 234 230 36 78 0.010 0.010 2 V2F 220 More 2010 N30*55.00' F74'35.16' 7.6 340 0.45 252 56 72 88 0.010 0.010 2 V2F 220 More 201 N30*55.05' F74'35.16'' 7.6 340 45 52 56 72 88 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 <t< td=""><td>14</td><td></td><td>V1N</td><td>110</td><td>HP 2012</td><td>N30°49.685'</td><td>E74°45.490'</td><td>7.9</td><td>826</td><td>0.40</td><td>390</td><td>142</td><td>20</td><td>78</td><td>0.010</td><td>0.010</td></t<>	14		V1N	110	HP 2012	N30°49.685'	E74°45.490'	7.9	826	0.40	390	142	20	78	0.010	0.010
16 V2 V2.X L20 Motor 2010 N3075.18 L24 L32 L34 L34 <thl34< th=""> <thl34< th=""> <t< td=""><td>15</td><td></td><td>V10</td><td>100</td><td>HP 2012</td><td>N30°49.730'</td><td>E74°45.515'</td><td>7.6</td><td>784</td><td>0.35</td><td>330</td><td>296</td><td>38</td><td>74</td><td>0.010</td><td>0.010</td></t<></thl34<></thl34<>	15		V10	100	HP 2012	N30°49.730'	E74°45.515'	7.6	784	0.35	330	296	38	74	0.010	0.010
17 V.28 160 Molor 2000 N.3075.85 Er.4*35.120 7.1 3.24 0.25 218 216 30 64 0.010 0.010 19 V.2D 180 Motor 2002 N.30755.307 F.74 376 0.40 224 226 36 64 0.010 0.010 21 V.2F 220 Motor 2015 N.5075.208 E7.4*35.017 7.6 2.4 2.6 2.6 850 118 12.0 0.010 0.010 0.010 22 V.26 150 Motor 2014 N.30*55.208 E7.4*35.017 8.0 1.180 0.55 2.6 2.5 1.78 3.0 1.8 1.2 0.010 0.010 23 V.3A 2.20 Motor 2014 N.30*9.272 E7.4*2.3.187 7.7 54 0.35 2.84 4.05 7.8 0.010 0.010 24 V.4D 2.00 Motor 2014 N.30*9.492.85 E7.4*2.3.087 7.5 3.16 0.	16	V2	V2A	120	Motor 2012	N30°55.186'	E74°35.320'	7.5	336	0.25	214	248	32	56	0.010	0.010
16 V2D 130 Motor 2002 NS055001 E/4 32,833 7.3 340 0.23 224 210 30 0.9 0.010 0.010 0.010 20 V2D 180 Motor 2002 NS055001 E/4 33,810 7.7 682 0.55 326 434 52 88 0.010 0.010 0.010 21 V2E 140 Motor 2010 NS0555005 E/4 33,817 7.7 682 0.55 226 238 30 128 0.010 0.010 0.010 21 V2E 60 Motor 2011 NS055205 E/4 33,687 7.8 634 0.45 352 7.8 80 0.010 0.010 0.010 24 V3 V3A 220 Motor 2011 N30*9526 E/4*23.587 7.7 34 0.35 288 446 62 98 0.010 0.010 25 V3E 70 HP 2015 N30*951847 E/4*23.597 7.9 448	1/		V2B	160	Motor 2006	N30°55.67	E/4°35.120 E74°25.855	/.1 7.5	324	0.35	1/8	192	26	40	0.010	0.010
10 Value 110 Motor 2015 N30*55296 Er4*35.870 7.7 682 0.53 204 20 20 20 20 20 20 20 20 20 20 20 20 0.010 0.010 21 V2F 120 Motor 2011 N30*55.208 Er4*35.871 8.0 1190 0.50 468 238 30 72 0.010 0.010 23 V2H 60 Motor 2001 N30*5.202 Er4*23.577 8.0 1190 0.50 468 352 526 830 0.010 0.010 24 V3 230 Motor 2011 N30*97.72 Er4*23.587 7.8 630 332 446 50 78 0.010 0.010 25 V3B 180 Motor 2011 N30*9.238 Er4*23.577 75 318 0.30 224 424 30 0.010 0.010 0.010 26 V3F Cass 78 M30*9	10		V2C V2D	120	Motor 2002	N30°55 001'	E74 33.833 E74°35 031'	7.5	340 376	0.23	228	210	36	04 78	0.010	0.010
1 V2F 220 More 2011 N39*55.509 E74*35.168 7.6 334 0.45 260 238 30 72 0.010 0.010 22 V2G 150 Moor 1997 N30*55.208 E74*35.067 K 1180 0.65 250 258 51 114 142 0.010 0.010 24 V3 V3A 220 Motor 2004 N30*9.772 E74*23.158 7.2 286 0.25 178 194 26 38 0.010 0.010 25 V3B 230 Motor 2011 N30*9.232 E74*23.158 7.7 534 0.35 288 446 50 78 0.010 0.010 26 V3C 1180 Motor 2011 N30*9.272 E74*23.078 7.5 318 0.30 224 252 66 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010	20		V2D V2E	140	Motor 2002	N30°55 296'	E74°35 870'	77	682	0.40	326	494	52	88	0.010	0.010
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	21		V2F	220	Motor 2011	N30°55.590'	E74°35.156'	7.6	354	0.45	260	238	30	72	0.012	0.010
21 V2H 60 Moter 2004 N30*3673F E14*35.76* 8.0 1100 0.50 4.68 730 94 126 0.010 0.010 25 V3B 230 Moter 2001 N30*3673F E14*23.532 7.7 634 0.35 288 446 54 82 0.010 0.010 26 V3D 180 Moter 2011 N30*39.72 E14*23.592 7.7 534 0.35 288 446 50 8 0.010 0.010 28 V3B 70 HP 2015 N30*39.318 E74*23.797 7.8 510 0.35 228 446 62 96 0.010 0.010 30 V4G 220 Motor 2010 N30*31.848 E74*23.502 7.0 180 0.55 322 246 0.25 0.65 322 246 0.010 0.010 31 V4D 310 Motor 2010 N30*13.80* E74*55.50* 7.0 180 0.55 <	22		V2G	150	Motor 2010	N30°55.208'	E74°35.081'	8.1	1380	0.65	526	850	118	142	0.011	0.010
24 V3 V3 232 Motor 2011 N30'49/72 E74'23.182 7.8 634 0.45 352 526 72 98 0.010 0.010 26 V3C 100 HP 2000 N30'49.724 E74'23.587 7.9 652 0.40 336 470 54 82 0.010 0.010 27 V3D 180 Motor 2011 N30'49.714 E74'23.576 7.8 540 0.45 312 448 62 0.010 0.010 29 V3F 22.5 Motor 2010 N30'49.218 E74'23.307 7.5 318 0.30 22 42.4 25.2 16.0 0.55 16.2 17.8 24.3 0.010 0.010 31 V4 V4A 200 Motor 2007 N30'51.848 E74'55.623 7.9 1400 0.70 34.3 18.4 16.0 13.2 44.8 0.010 0.010 0.010 33 V4C 350 Motor 2013	23		V2H	60	Motor 1997	N30°55.025'	E74°35.767'	8.0	1190	0.50	468	730	94	126	0.010	0.010
25 V3B 230 Motor 2011 N30'49/236 E'4'23.687 7.2 286 0.25 178 194 2.6 38 0.010 0.010 27 V3D 180 Motor 2011 N30'49/236 E'4'23.637 7.6 540 0.35 312 480 62 96 0.010 0.010 28 V3F 20 Motor 2015 N30'49.218 E'4'23.037 7.8 560 0.45 312 480 62 96 0.010 0.010 30 V3G 220 Motor 2015 N30'49.218 E'4'23.037 7.9 1360 0.65 322 264 36 178 0.010 0.010 31 V4 X4 200 Motor 2010 N30'51.865 E'4'55.612 8.2 170 0.85 368 210 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010	24	V3	V3A	220	Motor 2004	N30°49.674'	E74°23.432'	7.8	634	0.45	352	526	72	98	0.010	0.010
26 V3C 100 HP 2000 N3°49.236 E74'23.638 7.9 652 0.40 336 470 54 82 0.010 0.010 28 V3E 70 HP 2015 N3°49.218 E74'23.776 7.8 500 0.35 288 446 50 66 0.010 0.010 30 V3E 225 Motor 2015 N3°49.218 E74'23.395 7.0 246 0.25 162 178 24 32 0.010 0.010 31 V4 V4A 200 Motor 2007 N3°51.848 E74'55.567 7.9 1400 0.85 458 312 44 200 0.010 0.010 33 V4C 350 Motor 2013 N3°51.867 E74'55.569 7.9 1400 0.78 368 250 34 122 0.98 0.010 0.010 36 V4E 200 Motor 2013 N3°51.861 E74'55.561 7.8 140 0.30	25		V3B	230	Motor 2011	N30°49.772'	E74°23.198'	7.2	286	0.25	178	194	26	38	0.010	0.010
27 V3D 180 Motor 2011 N0 ³ 9,724 E74'23,792 7,7 534 0.35 228 446 50 78 60.01 0.010 0.010 29 V3F 225 Motor 2010 N30'49,925 E74'23,078 7.5 318 0.30 224 252 36 68 0.010 0.010 31 V4 V4A 200 Motor 2010 N30'51.848 E74'55.623 7.9 1380 0.65 322 264 36 178 0.010 0.010 32 V4B 350 Motor 2010 N30'51.867 E74'55.509 7.9 140 0.70 316 248 30 186 0.010 0.010 34 V4D 310 Motor 2017 N30'51.867 E74'55.567 7.9 140 0.80 386 254 32 198 0.020 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.0	26		V3C	100	HP 2000	N30°49.236'	E74°23.638'	7.9	652	0.40	336	470	54	82	0.010	0.010
28 V3E 70 HP 2015 No0*949.518 E/4*23.76 7.5 310 480 62 96 0.011 0.010 30 V3G 220 Motor 2015 N30*49.218 E74*23.395 7.0 246 0.25 162 178 24 32 0.010 0.010 0.010 31 V4 V4A 200 Motor 2010 N30*51.848 E74*55.595 7.9 1380 0.65 322 226 36 0.010 0.010 0.010 32 V4B 350 Motor 2010 N30*51.861 E74*55.595 7.9 1400 0.70 316 248 30 186 0.010 0.010 35 V4E 250 Motor 2013 N30*51.861 E74*55.564 7.8 1490 0.83 828 40 216 0.010 0.010 36 V4E 200 Motor 2017 N30*51.971 E74*55.564 7.8 140 0.30 216 0.010	27		V3D	180	Motor 2011	N30°49.724'	E74°23.592'	7.7	534	0.35	288	446	50	78	0.010	0.010
29 V1P 223 Molor 2010 N30*99/218 E74*23.05 7.0 244 0.25 162 178 0.010 0.010 31 V4 V4A 200 Motor 2007 N30*91.804 E74*25.623 7.9 1380 0.65 322 264 36 178 0.010 0.010 32 V4B 350 Motor 2009 N30*51.807 E74*55.504 7.9 1400 0.70 316 248 30 186 0.010 0.010 34 V4D 310 Motor 2013 N30*51.867 E74*55.564 7.8 1490 0.80 368 250 34 192 0.010 0.010 35 V4E 200 Motor 2007 N30*51.897 E74*55.564 7.8 1490 0.75 366 254 32 198 0.020 0.010 0.010 36 V4H 700 Motor 2014 N30*51.987 E74*55.564 7.8 1400 0.75 346	28		V3E V2E	70	HP 2015	N30°49.518'	E/4°23.776	7.8	560 219	0.45	312	480	62	96	0.011	0.010
10 100	29		V SF V3G	225	Motor 2010	N30°49.925 N30°40 218'	E74°23.078	7.5	518 246	0.30	224	232 178	30 24	08 32	0.010	0.010
14. Vit 200 Motor 2010 N30*51.848 E74*55.62 2.8 170 1.03 0.85 4458 312 44 260 0.010 0.010 33 V4C 350 Motor 2009 N30*51.870 E74*55.595 7.9 1400 0.70 316 248 30 186 0.010 0.010 34 V4D 310 Motor 2013 N30*51.861' E74*55.595 7.9 1400 0.80 368 250 34 192 0.010 0.010 36 V4F 200 Motor 2013 N30*51.922' E74*55.626 8.0 1550 1.00 348 24 128 40 0.010 0.010 37 V4G 300 Motor 2015 N30*51.988' E74*55.601'''.7.6 534 0.30 218 62 16 54 0.010 0.010 41 V4K 250 Motor 2015 N30*51.988'' E74*55.638'''.7.9 170 55 221 164<	31	V4	V4A	220	Motor 2013	N30°51 804'	E74°55 623'	7.0	1380	0.25	322	264	36	178	0.010	0.010
33 V4C 350 Motor 2009 N30*51.870 E74*55.595 7.9 1400 0.70 316 248 30 186 0.010 0.010 34 V4D 310 Motor 2016 N30*51.867 E74*55.609 8.1 1610 1.00 432 276 38 234 0.020 0.010 35 V4E 200 Motor 2017 N30*51.839 E74*55.626 8.0 1550 1.00 394 288 40 216 0.010 0.010 37 V4G 300 Motor 2009 N30*51.971 E74*55.501 7.9 1420 0.75 336 254 32 198 0.020 0.010 0.010 39 V41 330 Motor 2014 N30*51.036* E74*55.638* 7.8 190 0.75 346 170 24 168 0.010 0.010 41 V4K 250 Motor 2015 N30*52.054* E74*55.638* 7.8 1120 0.65	32	• •	V4B	350	Motor 2010	N30°51.848'	E74°55.612'	8.2	1740	0.85	458	312	44	260	0.010	0.010
34 V4D 310 Motor 2016 N30°51.861 E74°55.694 8.1 1610 1.00 432 276 38 234 0.020 0.010 35 V4E 250 Motor 2013 N30°51.861 E74°55.626 8.0 1550 1.00 304 228 40 0.010 0.010 36 V4F 200 Motor 2013 N30°51.922 E74°55.626 8.0 1550 1.00 334 228 40 216 0.010 0.010 38 V4H 700 Motor 2014 N30°51.917 F74'55.591 7.6 534 0.30 218 62 16 54 0.010 0.010 40 V4L 240 Motor 2015 N30°51.036 E74*55.637 7.8 1120 0.65 274 138 22 116 0.010 0.010 41 V4M 750 Motor 2015 N30°52.037 E74*37.624 7.5 632 0.35 230 84 1	33		V4C	350	Motor 2009	N30°51.870'	E74°55.595'	7.9	1400	0.70	316	248	30	186	0.010	0.010
55 V4E 250 Motor 2013 N30°51.861 E74°55.586 7.8 1490 0.80 368 250 34 192 0.010 0.010 36 V4F 200 Motor 2007 N30°51.839 E74°55.626 8.0 1500 1.00 394 288 40 216 0.010 0.010 37 V4G 300 Motor 2014 N30°51.921 E74°55.586 7.8 996 0.45 280 142 20 86 0.010 0.010 40 V4I 330 Motor 2014 N30°51.098 E74°55.637 7.8 1120 0.65 274 138 22 116 0.010 0.010 41 V4K 250 Motor 2015 N30°52.034 E74°55.637 7.8 1120 0.65 274 138 22 116 0.010 0.010 44 V4M 300 Motor 2006 N30°52.037 E74°55.637 7.8 1100 0.50 270 <t< td=""><td>34</td><td></td><td>V4D</td><td>310</td><td>Motor 2016</td><td>N30°51.865'</td><td>E74°55.609'</td><td>8.1</td><td>1610</td><td>1.00</td><td>432</td><td>276</td><td>38</td><td>234</td><td>0.020</td><td>0.010</td></t<>	34		V4D	310	Motor 2016	N30°51.865'	E74°55.609'	8.1	1610	1.00	432	276	38	234	0.020	0.010
36 V4F 200 Motor 2007 N30°51.839 E74°55.601 7.9 1420 0.75 336 254 32 198 0.00 0.010 37 V4G 300 Motor 2009 N30°51.971 E74°55.601 7.9 1420 0.75 336 254 32 198 0.010 0.010 39 V4I 300 Motor 2014 N30°51.071 E74°55.586 7.8 96 0.45 280 142 20 86 0.010 0.010 40 V4I 240 Motor 2015 N30°51.098 E74°55.638 7.9 1170 0.55 221 164 26 132 0.010 0.010 41 V4K 250 Motor 2016 N30°52.054 E74°55.638 7.9 1170 0.55 221 164 0.010 0.010 44 V4M 300 Motor 2006 N30°52.013 E74°37.624 7.5 492 0.25 200 276 34 4	35		V4E	250	Motor 2013	N30°51.861'	E74°55.584'	7.8	1490	0.80	368	250	34	192	0.010	0.010
37 V4G 300 Motor 2013 N30°51.921' E74°55.601' 7.9 1420 0.75 336 254 32 198 0.020 0.010 38 V4H 700 Motor 2014 N30°51.971' E74°55.580' 7.6 534 0.30 218 62 16 54 0.010 0.010 40 V44 330 Motor 2014 N30°51.090' E74°55.638' 7.9 1170 0.55 221 164 26 132 0.010 0.010 41 V4K 250 Motor 2015 N30°51.036' E74°55.638' 7.8 1120 0.65 274 138 22 116 0.010 0.010 43 V4M 750 Motor 2006 N30°52.033' E74°55.638' 7.5 652 0.35 230 84 16 72 0.012 0.010 44 V4O 300 Motor 2006 N30°52.033' E74°37.609' 8.1 1190 0.65 348 712 126 164 0.010 0.010 47 V5B <	36		V4F	200	Motor 2007	N30°51.839'	E74°55.626'	8.0	1550	1.00	394	288	40	216	0.010	0.010
38 V4H 700 Motor 2009 N30°51.971 E74°55.591 7.6 5.34 0.30 218 62 16 54 0.010 0.010 39 V4I 330 Motor 2014 N30°51.098 E74°55.568 7.8 996 0.45 280 142 20 86 0.010 0.010 41 V4K 250 Motor 2014 N30°51.036 E74°55.638 7.9 1170 0.55 221 164 26 132 0.010 0.016 42 V4L 350 Motor 2015 N30°52.034 E74°55.637 7.8 1120 0.65 274 138 22 116 0.010 0.010 44 V4M 300 Motor 2006 N30°52.033 E74°55.616 7.9 1080 0.50 270 132 20 84 0.010 0.010 45 V4O 300 Motor 2006 N30°55.003 E74°37.692 7.5 492 0.25 220 276 34 46 0.010 0.010 46 V5C 200	37		V4G	300	Motor 2013	N30°51.922'	E74°55.601'	7.9	1420	0.75	336	254	32	198	0.020	0.010
39 V41 330 Motor 2014 N30° 52.010 E/4°55.586 7.8 996 0.45 280 142 20 86 0.010 0.010 41 V4K 250 Motor 2014 N30°51.009' E74°55.637 7.8 1300 0.75 346 170 24 168 0.011 0.010 42 V4L 350 Motor 2016 N30°51.036' E74°55.637 7.8 1120 0.65 274 138 22 116 0.010 0.010 43 V4M 300 Motor 2015 N30°52.033' E74°55.616 7.9 1080 0.50 270 132 20 84 0.010 0.010 44 V4N 300 Motor 2006 N30°56.907' E74°37.609' 8.1 1190 0.65 348 712 126 164 0.010 0.010 47 V5B 250 Motor 2010 N30°55.001' E74°37.578' 7.5 492 0.25 202	38		V4H	700	Motor 2009	N30°51.971'	E74°55.591'	7.6	534	0.30	218	62	16	54	0.010	0.010
40 $V4k$ 240Molor 2013NS0 51.986E/4 53.008E/4 53.0088.031.3900.73346170241680.0110.01041V4K250Motor 2016N30°51.036'E74°55.6377.811200.55221164261320.0100.01643V4M750Motor 2015N30°52.034'E74°55.6377.811200.65274138221160.0100.01044V4N300Motor 2006N30°52.033'E74°55.613'7.810800.5027013220840.0100.01045V4O300Motor 2006N30°52.019'E74°57.623'7.810400.4525611820780.0100.01047V5B250Motor 2007N30°57.003'E74°37.624'7.75320.3024621830580.0100.01048V5C200Motor 2010N30°55.001'E74°31.193'8.113001.10542716983240.0100.01050V6B500Motor 2017N30°55.01'E74°31.193'7.43720.3021625814380.0100.01051V6C60HP 2017N30°55.01'E74°31.181'7.43720.3021625814380.0100.01052V6D60HP 2017N30°55.213'E74°31.181	39		V41	330	Motor 2014	N30°52.010'	E74°55.586'	7.8	996	0.45	280	142	20	86	0.010	0.010
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	40		V4J V4K	240	Motor 2015	N30°51.988	E/4°55.608	8.0 7.0	1390	0.75	340 221	170	24	108	0.011	0.010
12 143 144 143 144 145 145 145 145 145	41		V4K V4I	350	Motor 2014	N30°51 036'	E74 55.058 F74°55 637'	7.9	1170	0.55	221	138	20	132	0.010	0.010
44V4N300Motor 2008N30*52.033E74*55.6167.910800.5027013220840.0100.01045V4O300Motor 2006N30*52.019E74*55.6167.910800.5525611820780.0100.01046V5V5A200Motor 2006N30*56.907E74*37.6098.111900.653487121261640.0100.01047V5B250Motor 2010N30*57.003'E74*37.5787.75320.3024621830580.0100.01048V5C200Motor 2017N30*55.001'E74*37.578'7.75320.3024621830580.0100.01050V6B500Motor 2017N30*55.001'E74*31.193'7.02840.251506614380.0100.01051V6C60HP 2017N30*55.27E74*31.181'7.43720.30216228234460.0200.01052V6D60HP 2010N30*55.213'E74*31.187'7.54920.3528436042860.0100.01654V6F50HP 2016N30*55.049'E74*31.187'7.54920.3528436042860.0100.01055V6G80Motor 2002N30*55.049'E74*31.187'7.5492	43		V4M	750	Motor 2015	N30°52.054'	E74°55.638'	7.5	652	0.35	230	84	16	72	0.012	0.010
45 V4O 300 Motor 2006 N30°52.019 E74°55.623' 7.8 1040 0.45 256 118 20 78 0.010 0.010 46 V5 V5A 200 Motor 2007 N30°57.003' E74°37.609' 8.1 1190 0.65 348 712 126 164 0.010 0.010 47 V5B 220 Motor 2017 N30°57.03' E74°37.578' 7.5 492 0.25 220 276 34 46 0.010 0.010 48 V5C 200 Motor 2017 N30°55.001' E74°31.193' 8.1 1300 1.10 542 716 98 324 0.010 0.010 50 V6B 500 Motor 2017 N30°55.01' E74°31.187' 7.5 486 0.40 258 294 36 62 0.010 0.010 51 V6C 60 HP 2017 N30°55.141' E74°31.187' 7.5 492 0.35 284 360 42 86 0.010 0.010 55 56 HP 2016	44		V4N	300	Motor 2008	N30°52.033'	E74°55.616'	7.9	1080	0.50	270	132	20	84	0.010	0.010
46 V5 V5A 200 Motor 2006 N30°56.907' E74°37.609' 8.1 1190 0.65 348 712 126 164 0.010 0.010 47 V5B 250 Motor 2007 N30°57.003' E74°37.624' 7.5 492 0.25 220 276 34 46 0.010 0.010 48 V5C 200 Motor 2010 N30°55.001' E74°37.524' 7.5 492 0.25 220 276 34 46 0.010 0.010 49 V6 V6A 60 HP 2009 N30°55.001' E74°31.193' 7.0 284 0.25 150 66 14 38 0.010 0.010 51 V6C 60 HP 2017 N30°55.327' E74°31.181' 7.4 372 0.30 216 258 294 36 62 0.010 0.010 52 V6D 60 HP 2016 N30°55.213' E74°31.464' 7.8 910 0.45 362 488 54 112 0.010 0.010 0.010	45		V4O	300	Motor 2006	N30°52.019'	E74°55.623'	7.8	1040	0.45	256	118	20	78	0.010	0.010
47V5B250Motor 2007N30°57.003' $E74°37.624'$ 7.54920.2522027634460.0100.01048V5C200Motor 2010N30°56.878' $E74°37.578'$ 7.75320.3024621830580.0100.01049V6V6A60HP 2009N30°55.001' $E74°31.193'$ 8.113001.10542716983240.0100.01050V6B500Motor 2017N30°55.001' $E74°31.193'$ 7.02840.251506614380.0100.01051V6C60HP 2017N30°55.327' $E74°31.183'$ 7.54860.4025829436620.0100.01053V6E65HP 2010N30°55.213' $E74°31.464'$ 7.89100.45362488541120.0100.01054V6F50HP 2016N30°55.049' $E74°31.464'$ 7.89100.45362488541120.0100.01055V6G80Motor 2002N30°55.049' $E74°31.193'$ 7.76220.4531847052840.0120.01056V6H40HP 2001N30°55.049' $E74°31.193'$ 7.76220.4531847052840.0100.01057V6I80Motor 2007N30°55.049' $E74°31.193'$ <	46	V5	V5A	200	Motor 2006	N30°56.907'	E74°37.609'	8.1	1190	0.65	348	712	126	164	0.010	0.010
48V5C200Motor 2010N30°56.878' $E74^\circ 37.578'$ 7.75320.3024621830580.0100.01049V6V6A60HP 2009N30°55.001' $E74^\circ 31.193'$ 8.113001.10542716983240.0100.01050V6B500Motor 2017N30°55.001' $E74^\circ 31.193'$ 7.02840.251506614380.0100.01051V6C60HP 2017N30°55.327' $E74^\circ 31.131'$ 7.43720.3021625832460.0200.01053V6E65HP 2010N30°55.327' $E74^\circ 31.187'$ 7.54920.3528436042860.0100.01654V6F50HP 2016N30°55.202' $E74^\circ 31.464'$ 7.89100.45362488541120.0100.01055V6G80Motor 2002N30°55.020' $E74^\circ 31.464'$ 7.89100.45362488541120.0100.01056V6H40HP 2001N30°55.020' $E74^\circ 31.193'$ 7.76220.4531847052840.0100.01057V6I80Motor 2007N30°55.020' $E74^\circ 31.193'$ 7.43300.2521624230480.0100.01058V6J80Motor 2017N30°55.063' E	47		V5B	250	Motor 2007	N30°57.003'	E74°37.624'	7.5	492	0.25	220	276	34	46	0.010	0.010
49 V6 V6A 60 HP 2009 N30°55.001' E74°31.193' 8.1 1300 1.10 542 716 98 324 0.010 0.010 50 V6B 500 Motor 2017 N30°55.001' E74°31.193' 7.0 284 0.25 150 66 14 38 0.010 0.010 51 V6C 60 HP 2017 N30°55.327' E74°31.082' 7.5 486 0.40 258 294 36 62 0.010 0.010 53 V6E 65 HP 2010 N30°55.202' E74°31.187' 7.5 486 0.40 258 294 36 62 0.010 0.010 54 V6F 50 HP 2016 N30°55.202' E74°31.464' 7.8 910 0.45 362 488 54 112 0.010 0.010 55 V6G 80 Motor 2002 N30°55.049' E74°31.193' 7.7 622 0.45 318 470 52 84 0.012 0.010 57 V6I 8	48		V5C	200	Motor 2010	N30°56.878'	E74°37.578'	7.7	532	0.30	246	218	30	58	0.010	0.010
50 V6B 500 Motor 2017 N30*55.001 E74*31.193 7.0 284 0.25 150 66 14 38 0.010 0.010 51 V6C 60 HP 2017 N30*55.342' E74*31.131' 7.4 372 0.30 216 258 32 46 0.020 0.010 52 V6D 60 HP 2017 N30*55.327' E74*31.082' 7.5 486 0.40 258 294 36 62 0.010 0.010 53 V6E 65 HP 2010 N30*55.141' E74*31.187' 7.5 492 0.35 284 360 42 86 0.010 0.010 54 V6F 50 HP 2016 N30*55.202' E74*31.464' 7.8 910 0.45 362 488 54 112 0.010 0.010 55 V6G 80 Motor 2002 N30*55.020' E74*31.193' 7.7 622 0.45 318 470 52 84 0.010 0.010 57 V6I 80 Motor	49	V6	V6A	60 500	HP 2009	N30°55.001'	E74°31.193'	8.1	1300	1.10	542	716	98	324	0.010	0.010
51 $V6C$ 60 $HP 2017$ $N30^{\circ}5.3.242$ $E74^{\circ}31.131$ 7.4 372 0.30 216 238 32 46 0.020 0.010 52 $V6D$ 60 $HP 2017$ $N30^{\circ}55.327$ $E74^{\circ}31.082$ 7.5 486 0.40 258 294 36 62 0.010 0.010 53 $V6E$ 65 $HP 2010$ $N30^{\circ}55.131$ $E74^{\circ}31.187$ 7.5 492 0.35 284 360 42 86 0.010 0.016 54 $V6F$ 50 $HP 2016$ $N30^{\circ}55.213$ $E74^{\circ}31.464$ 7.8 910 0.45 362 488 54 112 0.010 0.010 55 $V6G$ 80 Motor 2002 $N30^{\circ}55.022$ $E74^{\circ}31.462$ 7.9 874 0.60 330 536 72 98 0.010 0.010 56 $V6H$ 40 $HP 2001$ $N30^{\circ}55.049$ $E74^{\circ}31.193$ 7.7 622 0.45 318 470 52 84 0.012 0.010 57 $V6I$ 80 Motor 2007 $N30^{\circ}55.049$ $E74^{\circ}31.193$ 7.4 330 0.25 216 242 30 48 0.010 0.010 58 $V6J$ 80 Motor 2013 $N30^{\circ}55.063$ $E74^{\circ}31.203$ 7.3 320 0.30 166 178 26 40 0.010 0.010 61 $V6M$ 200 Motor 2012 $N30^{\circ}55.063$ $E74^{$	50		V6B	500	Motor 2017	N30°55.001'	E/4°31.193	7.0	284	0.25	150	66 259	14	38	0.010	0.010
32 $V6D$ 60 $HP 2017$ $N30^{\circ} 53.527$ $E74^{\circ} 31.087$ 7.5 480 0.40 233 294 36 622 0.010 0.016 53 $V6E$ 65 $HP 2010$ $N30^{\circ} 55.141'$ $E74^{\circ} 31.187'$ 7.5 492 0.35 284 360 42 86 0.010 0.016 54 $V6F$ 50 $HP 2016$ $N30^{\circ} 55.213'$ $E74^{\circ} 31.464'$ 7.8 910 0.45 362 488 54 112 0.010 0.010 55 $V6G$ 80 Motor 2002 $N30^{\circ} 55.202'$ $E74^{\circ} 31.462'$ 7.9 874 0.60 330 536 72 98 0.010 0.010 56 $V6H$ 40 $HP 2001$ $N30^{\circ} 55.049'$ $E74^{\circ} 31.193'$ 7.7 622 0.45 318 470 52 84 0.012 0.010 57 $V6I$ 80 Motor 2007 $N30^{\circ} 55.049'$ $E74^{\circ} 31.193'$ 7.4 330 0.25 216 242 30 48 0.010 0.010 58 $V6J$ 80 Motor 2013 $N30^{\circ} 55.063'$ $E74^{\circ} 31.207'$ 7.9 616 0.50 374 450 56 92 0.010 0.010 60 $V6K$ 60 Motor 2012 $N30^{\circ} 55.063'$ $E74^{\circ} 31.203'$ 7.3 320 0.30 166 178 26 40 0.010 0.010 61 $V6M$ 200	51		VOC VGD	60	HP 2017	N30°55.342	E/4 ⁻ 31.131 E74°21.092'	7.4	312	0.30	210	204	32 26	40 62	0.020	0.010
54V6F50HP 2016N30°55.213'E74°31.464'7.89100.45362488541120.0100.01055V6G80Motor 2002N30°55.202'E74°31.464'7.89100.45362488541120.0100.01056V6H40HP 2001N30°55.020'E74°31.462'7.98740.6033053672980.0100.01056V6H40HP 2001N30°55.049'E74°31.193'7.76220.4531847052840.0120.01057V6I80Motor 2007N30°55.049'E74°31.193'7.43300.2521624230480.0100.01058V6J80Motor 2007N30°55.052'E74°31.207'7.96160.5037445056920.0100.01059V6K60Motor 2012N30°55.060'E74°31.203'7.33200.3016617826400.0100.01061V6M200Motor 2015N30°55.027'E74°31.203'7.53460.3517819028440.0110.01062V6N160Motor 2012N30°55.027'E74°31.203'7.53460.3517819028440.0100.01063V6O255Motor 2017N30°55.027'E74°31.203'7.5346 <td< td=""><td>52</td><td></td><td>V6E</td><td>65</td><td>HP 2017</td><td>N30°55 141'</td><td>E74°31 187'</td><td>7.5</td><td>480</td><td>0.40</td><td>238</td><td>360</td><td>42</td><td>86</td><td>0.010</td><td>0.010</td></td<>	52		V6E	65	HP 2017	N30°55 141'	E74°31 187'	7.5	480	0.40	238	360	42	86	0.010	0.010
55V6G80Motor 2002N30°55.202' $E74°31.462'$ 7.98740.6033053672980.0100.01056V6H40HP 2001N30°55.049' $E74°31.193'$ 7.76220.4531847052840.0120.01057V6I80Motor 2005N30°55.049' $E74°31.193'$ 7.43300.2521624230480.0100.01058V6J80Motor 2007N30°55.052' $E74°31.197'$ 7.65480.4029043248760.0100.01059V6K60Motor 2013N30°55.063' $E74°31.207'$ 7.96160.5037445056920.0100.01060V6L220Motor 2012N30°55.038' $E74°31.203'$ 7.33200.3016617826400.0100.01061V6M200Motor 2012N30°55.027' $E74°31.203'$ 7.53460.3517819028440.0110.01062V6N160Motor 2012N30°55.027' $E74°31.203'$ 7.53460.3517819028440.0110.01063V6O255Motor 2017N30°55.027' $E74°31.203'$ 7.53460.3517819028440.0110.01064V6P65Motor 2007N30°55.027' $E74°31.208'$ <t< td=""><td>54</td><td></td><td>V6F</td><td>50</td><td>HP 2016</td><td>N30°55.213'</td><td>E74°31.464'</td><td>7.8</td><td>910</td><td>0.45</td><td>362</td><td>488</td><td>54</td><td>112</td><td>0.010</td><td>0.010</td></t<>	54		V6F	50	HP 2016	N30°55.213'	E74°31.464'	7.8	910	0.45	362	488	54	112	0.010	0.010
56 V6H 40 HP 2001 N30°55.049' E74°31.193' 7.7 622 0.45 318 470 52 84 0.012 0.010 57 V6I 80 Motor 2005 N30°55.049' E74°31.193' 7.4 330 0.25 216 242 30 48 0.010 0.010 58 V6J 80 Motor 2007 N30°55.052' E74°31.197' 7.6 548 0.40 290 432 48 76 0.010 0.010 59 V6K 60 Motor 2013 N30°55.060' E74°31.207' 7.9 616 0.50 374 450 56 92 0.010 0.010 60 V6L 220 Motor 2012 N30°55.060' E74°31.203' 7.3 320 0.30 166 178 26 40 0.010 0.010 61 V6M 200 Motor 2012 N30°55.027' E74°31.203' 7.5 346 0.35 178 19	55		V6G	80	Motor 2002	N30°55.202'	E74°31.462'	7.9	874	0.60	330	536	72	98	0.010	0.010
57 V6I 80 Motor 2005 N30°55.049' E74°31.193' 7.4 330 0.25 216 242 30 48 0.010 0.010 58 V6J 80 Motor 2007 N30°55.052' E74°31.197' 7.6 548 0.40 290 432 48 76 0.010 0.010 59 V6K 60 Motor 2013 N30°55.063' E74°31.207' 7.9 616 0.50 374 450 56 92 0.010 0.010 60 V6L 220 Motor 2012 N30°55.060' E74°31.203' 7.3 320 0.30 166 178 26 40 0.010 0.010 61 V6M 200 Motor 2015 N30°55.038' E74°31.203' 7.5 346 0.35 178 190 28 44 0.011 0.010 62 V6N 160 Motor 2012 N30°55.027' E74°31.208' 7.1 312 0.30 170 184 26 50 0.010 0.010 63 V6O 255 <td>56</td> <td></td> <td>V6H</td> <td>40</td> <td>HP 2001</td> <td>N30°55.049'</td> <td>E74°31.193'</td> <td>7.7</td> <td>622</td> <td>0.45</td> <td>318</td> <td>470</td> <td>52</td> <td>84</td> <td>0.012</td> <td>0.010</td>	56		V6H	40	HP 2001	N30°55.049'	E74°31.193'	7.7	622	0.45	318	470	52	84	0.012	0.010
58 V6J 80 Motor 2007 N30°55.052' E74°31.197' 7.6 548 0.40 290 432 48 76 0.010 0.010 59 V6K 60 Motor 2013 N30°55.063' E74°31.207' 7.9 616 0.50 374 450 56 92 0.010 0.010 60 V6L 220 Motor 2012 N30°55.060' E74°31.203' 7.3 320 0.30 166 178 26 40 0.010 0.010 61 V6M 200 Motor 2015 N30°55.038' E74°31.203' 7.5 346 0.35 178 190 28 44 0.011 0.010 62 V6N 160 Motor 2012 N30°55.027' E74°31.203' 7.5 346 0.35 178 190 28 44 0.011 0.010 63 V6O 255 Motor 2017 N30°55.027' E74°31.208' 7.1 312 0.30 170 <	57		V6I	80	Motor 2005	N30°55.049'	E74°31.193'	7.4	330	0.25	216	242	30	48	0.010	0.010
59 V6K 60 Motor 2013 N30°55.063' E74°31.207' 7.9 616 0.50 374 450 56 92 0.010 0.010 60 V6L 220 Motor 2012 N30°55.060' E74°31.203' 7.3 320 0.30 166 178 26 40 0.010 0.010 61 V6M 200 Motor 2015 N30°55.038' E74°31.203' 7.5 346 0.35 178 190 28 44 0.011 0.010 62 V6N 160 Motor 2012 N30°55.027' E74°31.189' 7.4 358 0.25 192 236 32 68 0.010 0.010 63 V6O 255 Motor 2017 N30°55.018' E74°31.208' 7.1 312 0.30 170 184 26 50 0.010 0.010 64 V6P 65 Motor 2007 N30°54.707' E74°32.167' 7.9 720 0.65 438 <	58		V6J	80	Motor 2007	N30°55.052'	E74°31.197'	7.6	548	0.40	290	432	48	76	0.010	0.010
60 V6L 220 Motor 2012 N30°55.060' E74°31.203' 7.3 320 0.30 166 178 26 40 0.010 0.010 61 V6M 200 Motor 2015 N30°55.038' E74°31.203' 7.5 346 0.35 178 190 28 44 0.011 0.010 62 V6N 160 Motor 2012 N30°55.027' E74°31.189' 7.4 358 0.25 192 236 32 68 0.010 0.010 63 V6O 255 Motor 2017 N30°55.018' E74°31.208' 7.1 312 0.30 170 184 26 50 0.010 0.010 64 V6P 65 Motor 2007 N30°54.707' E74°32.167' 7.9 720 0.65 438 546 70 118 0.010 0.010 65 V6Q 80 Motor 2000 N30°54.527' E74°32.203' 7.7 600 0.45 324	59		V6K	60	Motor 2013	N30°55.063'	E74°31.207'	7.9	616	0.50	374	450	56	92	0.010	0.010
b1 Vom 200 Motor 2015 N30°55.038' E/4°31.203' 7.5 346 0.35 178 190 28 44 0.011 0.010 62 V6N 160 Motor 2012 N30°55.027' E74°31.189' 7.4 358 0.25 192 236 32 68 0.010 0.010 63 V6O 255 Motor 2017 N30°55.018' E74°31.208' 7.1 312 0.30 170 184 26 50 0.010 0.010 64 V6P 65 Motor 2007 N30°54.707' E74°32.167' 7.9 720 0.65 438 546 70 118 0.010 0.016 65 V6Q 80 Motor 2000 N30°54.527' E74°32.203' 7.7 600 0.45 324 458 56 80 0.010 0.010 66 V6R 70 HP 2001 N30°54.948' E74°32.203' 8.1 1090 0.85 456 <td< td=""><td>60</td><td></td><td>V6L</td><td>220</td><td>Motor 2012</td><td>N30°55.060'</td><td>E74°31.203'</td><td>7.3</td><td>320</td><td>0.30</td><td>166</td><td>178</td><td>26</td><td>40</td><td>0.010</td><td>0.010</td></td<>	60		V6L	220	Motor 2012	N30°55.060'	E74°31.203'	7.3	320	0.30	166	178	26	40	0.010	0.010
62 Voin 160 Motor 2012 Nov 53.027 E/4 51.189 7.4 358 0.25 192 236 52 68 0.010 0.010 63 V6O 255 Motor 2017 N30°55.018' E74°31.208' 7.1 312 0.30 170 184 26 50 0.010 0.010 64 V6P 65 Motor 2007 N30°54.707' E74°32.167' 7.9 720 0.65 438 546 70 118 0.010 0.016 65 V6Q 80 Motor 2000 N30°54.527' E74°32.827' 7.7 600 0.45 324 458 56 80 0.010 0.010 66 V6R 70 HP 2001 N30°54.948' E74°32.203' 8.1 1090 0.85 456 90 134 0.010 0.010	61		V6M	200	Motor 2015	N30°55.038'	E/4°31.203'	7.5	346	0.35	1/8	190	28	44	0.011	0.010
64 V6P 65 Motor 2007 N30°54.707' E74°32.167' 7.9 720 0.65 438 546 70 118 0.010 0.010 65 V6Q 80 Motor 2000 N30°54.527' E74°32.827' 7.7 600 0.45 324 458 56 80 0.010 0.010 66 V6R 70 HP 2001 N30°54.948' E74°32.203' 8.1 1090 0.85 456 90 134 0.010 0.010	62 63		V6N V6O	255	Motor 2012	N30°55.027'	E74°31.189' E74°31.208'	7.4	358	0.25	192	236	32 26	68 50	0.010	0.010
65 V6Q 80 Motor 2000 N30°54.527' E74°32.827' 7.7 600 0.45 324 458 56 80 0.010 0.010 66 V6R 70 HP 2001 N30°54.948' E74°32.203' 8.1 1090 0.85 456 90 134 0.010 0.010	64		V6P	65	Motor 2017	N30°54 707'	E74°32.167'	7.9	720	0.50	438	546	70	118	0.010	0.016
66 V6R 70 HP 2001 N30°54.948' E74°32.203' 8.1 1090 0.85 456 90 134 0.010 0.010	65		V60	80	Motor 2007	N30°54.527'	E74°32.827'	7.7	600	0.45	324	458	56	80	0.010	0.010
	66		V6R	70	HP 2001	N30°54.948'	E74°32.203'	8.1	1090	0.85	456		90	134	0.010	0.010

V1 = Shakoor; V2 = Naurang ke Sayal; V3 = Khunder Uttar; V4 = Talwandi Bhai; V5 = Ferozepur City; V6 = Rodewala

RESULTS AND DISCUSSION

Impurities in drinking water were detected by using improved analytical methods to ascertain the quality of drinking water. Table-1 denotes the results of physico-chemical parameters and heavy metals present in drinking water samples collected from selected sampling sites across district Ferozepur of Punjab state, India.

The results of some physico-chemical parameters like pH, TDS, alkalinity, total hardness, fluoride, chloride and some heavy metals like arsenic and lead are shown in Table-1. As per WHO guidelines, pH of drinking water should lie in between 6.5-8.5. The pH of water samples was found to lie in between 7.0 to 8.2 with mean pH 7.71 which was slightly alkaline. The minimum and maximum pH value of 7.0 and 8.2 was observed in the sample ID V3G and ID V4B, respectively.

High TDS values were observed at many locations. The acceptable limit of TDS in water is 1000 mg/L as per WHO standards. Twenty one samples (32 %) were found to have TDS more than 1000 mg/L with maximum TDS of 1740 mg/L in sample no. 32 (sub-tehsil Talwandi Bhai). The broad agricultural practices and large extraction of groundwater leads to high concentrations of dissolved materials which further increase value of TDS. High TDS is due to Na⁺, K⁺, Ca²⁺, Mg²⁺, CO₃²⁻, Cl⁻, *etc.* ions present in water.

The maximum permissible limit of total hardness in water is 600 mg/L as per WHO guidelines. About 88% of samples were found to have total hardness less than the maximum permissible limit. The total hardness of sample ID V2G was more than the permissible limit with maximum value of 850 mg/L.

The permissible limit for calcium is 75 mg/L as per WHO guidelines. Presence of calcium in sample ID V5A was more than the permissible limit with maximum value of 126 mg/L. As per WHO guidelines, the permissible limit of arsenic content is 0.010 mg/L and there are 19 % samples found to have arsenic

content more than permissible limit. Around 0.09 % samples found to have lead content beyond permissible limit that is 0.010 mg/L. Table-2 denotes the summary of water quality parameters of studied area.

Statistical analysis

Fluoride analysis: Groundwater samples contained fluoride concentration ranges from 0.25 to 1.20 mg/L with mean value and SD of 0.52 mg/L and 0.08575, respectively. As per analysis results, it was noted that no sample exceeded the acceptable limit (Table-3). The minimum fluoride concentration (0.6 mg/L) which prevents dental caries and encourages the development of bones and is unfit for drinking purpose. About 69.9 % of total samples found to have fluoride concentration below minimum fluoride concentration within permissible limits. Table-3 and Fig. 2 denotes the frequency distribution of fluoride against sampling area.

The study also revealed that the fluoride dissolution increases with respect to depth as there could be an increase in the geo-



Fig. 2. Concentration of fluoride and depth at various sampling sites

	TABLE-2 SUMMARY OF WATER QUALITY PARAMETERS OF STUDIED AREA													
Name of village	No. of sample	TDS (mg/L)	F (mg/L)	pH	Alkalinity (mg/L)	Total hardness (mg/L)	Ca ²⁺ (mg/L)	Cl⁻ (mg/L)	As ³⁺ (mg/L)	Pb ²⁺ (mg/L)				
V1	15	472-1160	0.25-1.20	7.3-8.1	236-514	142-426	20-42	46-156	0.010-0.020	0.010-0.010				
V2	8	324-1380	0.25-0.65	7.1-8.1	178-526	192-850	26-118	40-142	0.010-0.012	0.010-0.010				
V3	7	246-652	0.25-0.45	7.0-7.9	162-352	178-526	24-72	32-98	0.010-0.011	0.010-0.010				
V4	15	534-1740	0.30-1.00	7.5-8.2	221-458	62-312	16-44	54-260	0.010-0.020	0.010-0.010				
V5	3	492-1190	0.25-0.65	7.5-8.1	220-348	218-712	30-126	58-164	0.010-0.010	0.010-0.010				
V6	18	312-1300	0.25-1.10	7.0-8.1	150-542	66-716	14-98	38-324	0.010-0.020	0.010-0.016				
Total	66	246-1740	0.25-1.20	7.0-8.2	150-542	62-850	14-126	32-324	0.010-0.020	0.010-0.010				
Mean		793.82	0.52	7.71	314.20	305.06	40.64	101.82	0.0108	0.0107				

 TABLE-3

 FREQUENCY DISTRIBUTION OF WATER QUALITY PARAMETERS OF STUDIED AREA

	Name of village	No. of sample	F (mg/L)			Cl ⁻ (mg/L)			As^{3+} (mg/L)			Pb^{2+} (mg/L)		
S. No.			<1.0	1.0-1.5	>1.5	<250	250- 1000	>1000	<0.010	Equal to 0.010	>0.010	<0.010	Equal to 0.010	>0.010
1	V1	15	11	4	Nil	15	Nil	Nil	Nil	12	3	Nil	12	3
2	V2	8	8	Nil	Nil	8	Nil	Nil	Nil	6	2	Nil	8	Nil
3	V3	7	7	Nil	Nil	7	Nil	Nil	Nil	6	1	Nil	7	Nil
4	V4	15	13	2	Nil	15	Nil	Nil	Nil	11	4	Nil	14	1
5	V5	3	3	Nil	Nil	3	Nil	Nil	Nil	3	Nil	Nil	3	Nil
6	V6	18	17	1	Nil	18	Nil	Nil	Nil	15	3	Nil	16	2

thermal gradient. Although the observation on the interdependency between depth and fluoride concentration was positively correlated (Fig. 3), the lower fluoride concentration in groundwater may be associated with the mixing of water with different chemical compositions. The enrichment of fluoride is in shallow groundwater sources because of evapotranspiration and thus, the concentration of fluoride at deep groundwater sources is less.



Fig. 3. Relation b/w depth and fluoride at various sampling sites

Chloride analysis: Groundwater samples contained 32 to 324 mg/L of chloride concentration with mean and SD value of 101.82 mg/L and 26.266, respectively. The analysis data showed that no sample exceeded the acceptable limit (Table-3). 250 mg/L is the minimum chloride concentration which is needed to stop the harmful effects on metal pipes and agricultural implements and 96.97% of total samples found to have chloride concentration below minimum concentration.

The study showed that chloride concentration increases with increase in depth (Table-4). The relation between depth and chloride concentration is shown in Fig. 4. Due to weather conditions, the process of leaching of chloride from rocks into soil and water is done. Due to mobility characteristic of chloride ion, it is transported to closed oceans, hence, the concentration of chloride is high at deep groundwater sources.



Fig. 4. Relation b/w concentration of chloride and depth

Correlation analysis: The fluoride and chloride concentrations in groundwater showed significant relationship with pH and depth.

Effect of pH on fluoride and chloride: Fluoride concentration has showed a positive correlation with pH whereas chloride showed slightly negative trend with pH ($R^2 = 0.9975$ and 0.6804, respectively) (Table-5). The positive correlation between pH & fluoride and pH & chloride levels might be

THE ODIDE IN COOLINDWATER

	TABLE-4												
STATISTICAL ANALYSIS OF WATER SAMPLES													
Name of village	No. of samples	$F^{-}(mg/L)$	Range	Mean	SD	$Cl^{-}(mg/L)$	Range	Mean	SD				
V1	15	0.25-1.20	0.95	0.61	0.33922	46-156	110	96.0000	30.6874				
V2	8	0.25-0.65	0.40	0.425	0.14142	40-142	102	83.2500	34.7224				
V3	7	0.25-0.45	0.20	0.35	0.08660	32-98	66	70.2857	26.266				
V4	15	0.30-1.00	0.70	0.65	0.21630	54-260	206	150.267	65.6826				
V5	3	0.25-0.65	0.40	0.4	0.21794	58-164	106	89.3333	64.9410				
V6	18	0.25-1.10	0.85	0.456	0.22485	38-324	286	88.8889	65.1883				
Name of village	No. of samples	As ³⁺ (mg/L)	Range	Mean	SD	Pb ²⁺ (mg/L)	Range	Mean	SD				
V1	15	0.010-0.020	0.010	0.010	0.002499	0.010-0.010	0.000	0.012	0.00414				
V2	8	0.010-0.012	0.002	0.010	0.000744	0.010-0.010	0.000	0.010	0.00000				
V3	7	0.010-0.011	0.001	0.010	0.000377	0.010-0.010	0.000	0.010	0.00000				
V4	15	0.010-0.020	0.010	0.011	0.003481	0.010-0.010	0.000	0.010	0.00154				
V5	3	0.010-0.010	0.000	0.010	0.000000	0.010-0.010	0.000	0.010	0.00000				
V6	18	0.010-0.020	0.010	0.010	0.002371	0.010-0.016	0.006	0.010	0.00194				

TABLE-5

	ANOVA. SHOWING EFFECT OF PHONTECOMBE & CHECKBE IN ONOCHDWATER											
		DF	Sum of squares	Adjusted R ²	Mean square	F-value	F _{critical}					
Fluoride	Model	1	156.2206	0.997561	156.2206	10309.96	4.9646					
Fluoride	Error	10	0.151524		0.0151524							
Fluoride	Total	11	156.372124									
Chloride	Model	1	23570.8296	0.6804	23570.8296	61.01527	4.9646					
Chloride	Error	10	3863.1029		386.31029							
Chloride	Total	11	27433.9325									

due to the release of hydroxyl and bicarbonate ions simultaneously during the leaching and dissolution process of fluoridebearing minerals in the groundwater. The solubility of fluoride is lowest in the pH range of 5.0 to 5.6 due to its absorption on the surface of minerals present in clay in sub-surface rocks.

Effect of depth on fluoride and chloride: Fluoride and chloride have showed a negative and positive correlation with depth having $R^2 = 0.715517$ and 0.720376, respectively) (Table-6). High fluoride and low chloride concentrations have been found in the shallow surface waters, whereas fluoride concentration reduces with increase in depth, on the other hand, chloride concentration increases with increase in depth. Fluoride occurrence is due to geogenic as well as anthropogenic reasons but chloride occurrence is because of its build up during evaporation process in the soil because chloride is not taken up by plants and non-volatile. Chloride moves conservatively in liquid water throughout the hydrologic cycle.

Effect of depth on arsenic and lead: Arsenic and lead showed a negative correlation with depth having $R^2 = 0.04036$ and 0.215407, respectively) (Table-7). Arsenic concentration remains constant in majority of the samples and was found within permissible limit in 81 % samples as prescribed by WHO *i.e.* 0.010 mg/L, whereas the concentration of lead reduces with increase in depth and was found within permissible limit as prescribed by WHO *i.e.* in this case is 0.010 mg/L.

Water quality index: The quality of groundwater at certain places in Ferozepur district can also be ascertained by calcul-

ating water quality index. The methodology for computation of water quality index (WQI) includes following steps:

$$WQI = \frac{\Sigma W_n Q_n}{\Sigma W_n}$$

The quality rating index (Q_n) is calculated by using this expression:

$$\mathbf{Q}_{n} = \left(\frac{\mathbf{V}_{n} - \mathbf{V}_{i}}{\mathbf{S}_{n} - \mathbf{V}_{i}}\right) \times 100$$

where, V_n is estimated value of the parameters of groundwater in Ferozpur district; V_i is the ideal value of parameter in pure water; $V_i = 0$ (except pH = 7.0 for all other parameters); S_n is standard permissible value of parameter of groundwater. The unit weight (W_i) for each water quality parameter is calculated by using the following formula:

$$W_n = \frac{K}{S_n}$$

where, K is proportionality constant and can also be calculated by using the following equation:



The water quality index of groundwater in Ferozepur district is equal to 107 (Table-8). The value is close to 100 so

	TABLE-6 ANOVA: SHOWING EFFECT OF DEPTH ON FLUORIDE & CHLORIDE IN GROUNDWATER											
		DF	Sum of squares	Adjusted R ²	Mean square	F-value	F _{critical}					
Fluoride	Model	1	0.542384	0.715517	0.542384	70.4389	4.9646					
Fluoride	Error	10	0.077		0.0077							
Fluoride	Total	11	0.619384									
Chloride	Model	1	27809.976	0.720376	27809.976	71.99	4.9646					
Chloride	Error	10	3863.0284		386.3028							
Chloride	Total	11	31673.004									

TABLE-7 ANOVA: SHOWING EFFECT OF DEPTH ON ARSENIC & LEAD IN GROUNDWATER

		DF	Sum of squares	Adjusted R ²	Mean square	F-value	F _{critical}					
Arsenic	Model	1	0.006486	0.04036	0.006486	8.59	4.9646					
Arsenic	Error	10	0.007554		0.0007554							
Arsenic	Total	11	0.01404									
Lead	Model	1	0.00643107	0.215407	0.006431	14.8387	4.9646					
Lead	Error	10	0.00433396		0.000433396							
Lead	Total	11	0.011									

TABLE-8													
	WATER QUALITY INDEX OF GROUND WATER IN FEROZEPUR DISTRICT												
Parameters	V_i	S _n	1/S _n	Κ	\mathbf{W}_{n}	Q _n	$W_n \times Q_n$						
TDS (mg/L)	793.82	1000	0.001	0.00498	0.00000498	79.3818182	0.000395321						
F (mg/L)	0.52	1.5	0.666666667	0.00498	0.00332	34.66666667	0.115093333						
pН	7.71	8.5	0.117647059	0.00498	0.000585882	47.172	0.027637242						
Alkalinity (mg/L)	314.20	120	0.008333333	0.00498	0.0000415	261.8308081	0.010865979						
Total hardness (mg/L)	305.06	600	0.001666667	0.00498	0.0000083	50.84343435	0.000422001						
Ca^{2+} (mg/L)	40.64	75	0.013333333	0.00498	0.0000664	54.18181333	0.003597672						
$Cl^{-}(mg/L)$	101.82	250	0.004	0.00498	0.00001992	40.727248	0.000811287						
As^{3+} (mg/L)	0.0108	0.010	100	0.00498	0.498	108	53.784						
Pb^{2+} (mg/L)	0.0107	0.010	100	0.00498	0.498	107	53.286						
			$\Sigma 1/S_i = 200.8$		$\Sigma W_n = 1.00005$		$\Sigma W_n \times Q_n = 107.229$						

the quality of groundwater in Ferozepur district can be categorized under 'Good Quality' water.

Conclusion

The results of the study revealed that groundwater quality in north-west district of Punjab *i.e.* Ferozepur is having a small amount of fluoride and chloride contents in groundwater but majority of the samples are within the acceptable limits when the water samples were collected from depth ranging from 100 ft to 360 ft. The maximum fluoride concentration has been observed at shallow depths upto 100 ft. with decreasing trend afterwards suggesting that fluoride contamination decreases with increase in depth of groundwater beyond 100 ft. The studies showed that the chloride serves as a tracer of water movement. Evapotranspiration causes chloride to build up in the soil because chloride is not taken up by plants and is non-volatile. The concentration of chloride was found to be within limits at shallow depths and as well as depth upto 360 ft. The value of TDS in 32 % samples was found more than 1000 mg/L with maximum TDS of 1740 mg/L in sample at site no. 32 (sub-tehsil Talwandi Bhai). The concentration of arsenic was also found to be within permissible limits of WHO at any depth in 81 % samples while 19 % samples contain arsenic beyond permissible limit, whereas, the concentration of lead decreases with increase in depth. As the depth increases beyond 100 ft, concentration of lead lies within permissible limits in most of the samples. ANOVA has been applied on analysis results to study the effect of pH on fluoride and chloride, depth on fluoride and chloride and depth on arsenic and lead. The results showed that F-value is greater than F-critical in said correlation analysis which is in accordance with the results obtained. Also, to adjudge the overall quality of groundwater in Ferozepur district, the water quality index has been calculated on the basis of large number of physico-chemical characteristics of groundwater. This value of water quality index indicates that the groundwater quality in Ferozepur district of Punjab state can be considered of 'Good Quality' when the groundwater is used at the depth ranging from 100 ft to 360 ft.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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