iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VIII **Month of publication:** August 2017

DOI: http://doi.org/10.22214/ijraset.2017.8190

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Evaluation of Ground Water Quality in Nagpur City

Sujata S. Thergaonkar [1], Gauri D. Pardhi[2], Rubina K. Sheikh[3], Nain M. Sayyed[4], Vaishnavi P. Tambekar[5], Dr. V. P. Thergaonkar[6]
[1,2,3,4] *Enviro Techno Consult Pvt. Limited, Nagpur(ETCPL) (M.Sc. Env.Sc,)*
[5] *(B.Sc.-PCM) Trainee*
[6] *Ex.NEERI Scientist, Director*

Abstract: Paper contains information generated after detailed examination of routine chemical ground water quality data of 40 bore wells and 20 dug wells from different localities of Nagpur city. Additional information e.g. ionic strengths, saturation indices of ground water quality in Nagpur was computed from analyses for routine water quality. This information included a) ionic strengths of samples, ii) Langelier & Ryzner stability indices which would indicate whether concerned water is scale forming or corrosive, iii)carbon dioxide concentrations and iv)multiplying factor to convert conductivity(µS/cm) into total dissolved solids (mg/L) valid for Nagpur city . Dug wells represent relatively shallow water table in Nagpur and bore wells draw water from deeper aquifers. This study has shown i) Average ionic strengths of dug and bore wells were respectively 10.7 ± 3.9 and 14.2 ± 6.5. Ionic strength of dug well water from industrial areas was higher, probably due to non- point wastewater discharges over land, ii) dug well waters were found to be more corrosive due to carbon dioxide and iii) multiplying factor to convert conductivity(µS/cm) into total dissolved solids (mg/L) was 0.69 for dug wells and 0.73 for bore wells. These factors have been validated in subsequent analyses.
Evaluation of Groundwater quality in Nagpur

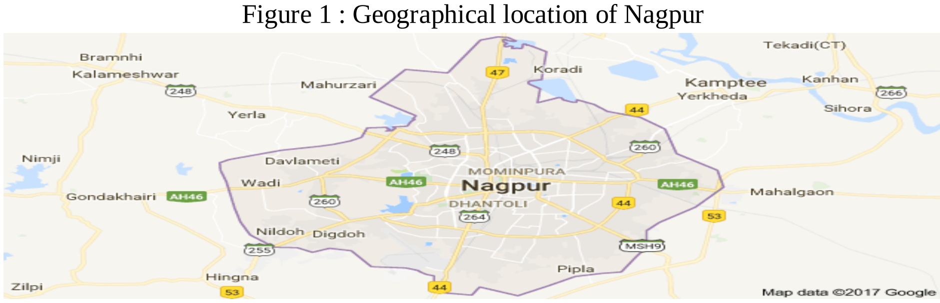
I. INTRODUCTION

Laboratory at Enviro Techno Consult Pvt. Ltd, Nagpur, recognised as an In house R & D Unit by D.S.I.R., DST, Govt. of India receives various requests from industries, household consumers, hospitals etc. within metropolitan area of Nagpur for detailed water analyses. They need water analysis reports to confirm if water/source being used by them is potable/fit for industrial use and to suggest treatment if warranted. It is the policy of this laboratory to first instruct clients on methods of collection of samples both for chemical and bacteriological analyses. Samples are accepted only if they are properly labelled for date of collection, the source and also the environs around source. It has been observed of late that there is increasing dependence of urban population on ground water for domestic consumption, particularly in the expanding urban-fringe areas of Nagpur. Hence more samples are being collected from newer localities.

A. Area Covered

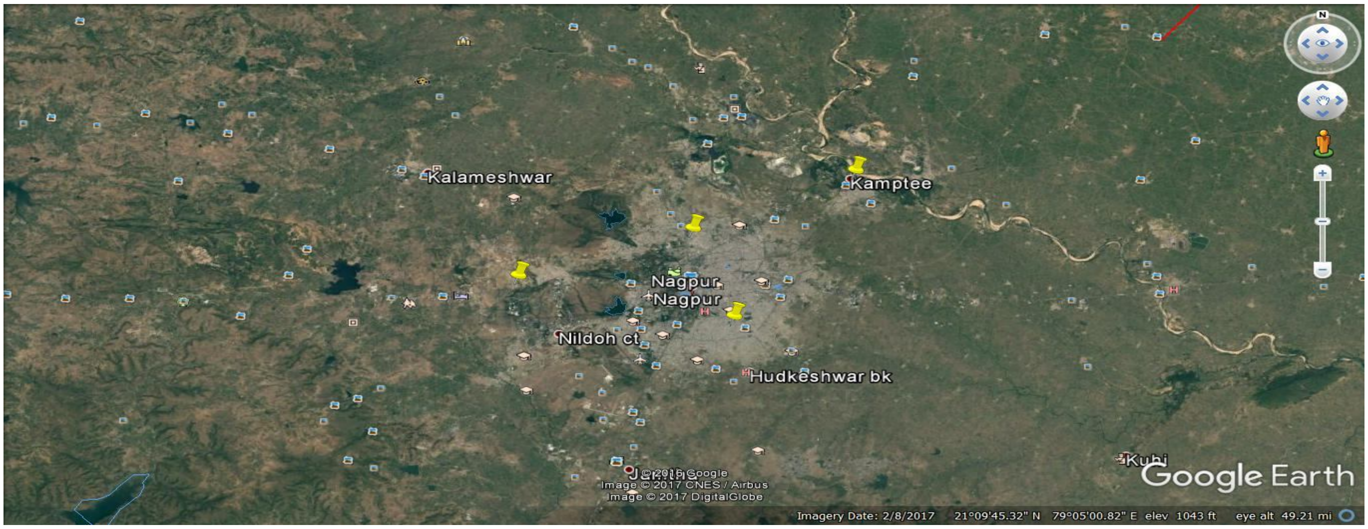
This paper deals with groundwater quality in and around Nagpur city. Geographical location of Nagpur is shown in Figure1. Topographical features around Nagpur city are shown in the satellite imagery in Figure2**.** Zero milestone located in city is considered a centre of India. Topographical features with reference to 'Zero mile stone' in Nagpur centre are i) River Kanhan flowing from N to SE at about 25 km, ii) river Kolar at Koradi, iii) man-made lakes at Ambazari to W, Futala to NW, Shukrawar/jumma tank, iii) the Nag & Pilli rivers carrying sullage/wastewater from residential areas along their banks etc. and iv) Industrial areas at Hingna to west, Butibori to south and Uppalwadi north east of Nagpur.

Figure 1 : Geographical location of Nagpur



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Figure 2 : Topography around Nagpur



B. Objective

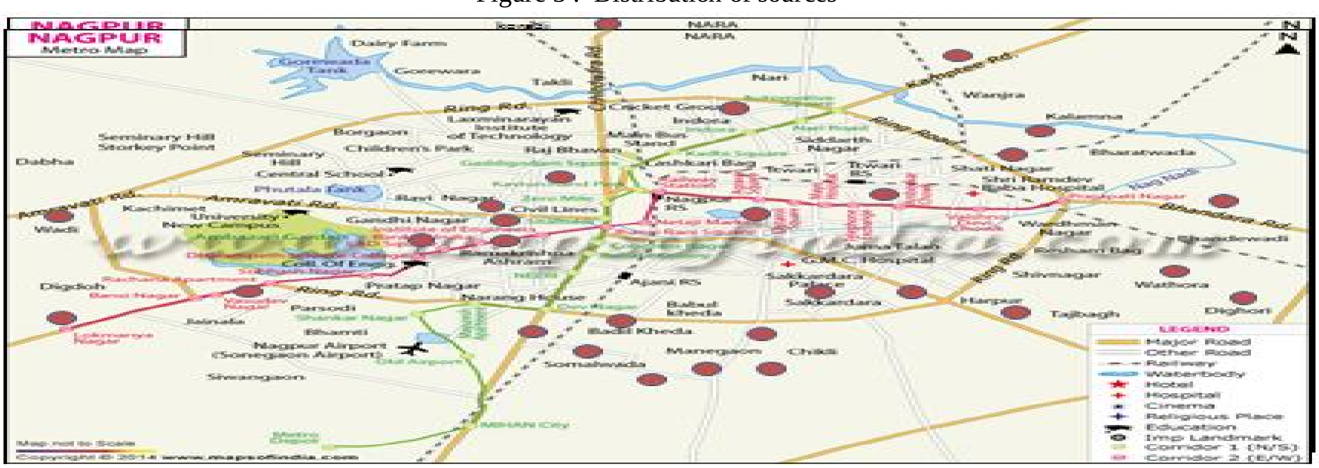
Purpose examination of ground water – analyses- reports was to present an over view of chemical quality ground water in & around Nagpur. Some useful conclusions have been drawn with respect to ground water quality of Nagpur ground water samples. Ground water quality is influenced by geology around a source.

Occurrence and movement of groundwater depends upon the rock formation of the area and is influenced by i) inter granular primary porosity & permeability, ii)thickness and extent of weathered zones, iii) topographic setting of the area, iv) surface water bodies influencing groundwater recharge and v) development of joints, fractures, lineaments constituting secondary permeability. Metamorphic rocks predominate in Nagpur region. Geologically, Nagpur city is almost the dividing line between Archean rocks exposed to the east and younger formations, viz., Deccan-basalts, the infra-trappean Lametas and the Gondwanas on the west. Stratigraphic sequence in Nagpur city is soil, basalt flows with intra- trappean sediments to NE/S/ SW &Lameta beds (NW), Gondwana(N & NE). Pre and post monsoon ground water levels in Nagpur city are respectively 8.2 and 3.2 m below ground level.

C. Approach

In this paper, ground water sources have been categorised in two types. First is dug wells representing relatively shallow aquifer and the second is bore wells /hand pumps -which draw water from relatively deeper aquifers. Results of analyses for routine water quality parameters from these sources were used to compare water quality in deep and shallow aquifers in and around Nagpur city. Localities from where samples were received are shown in Figure 3**.**

Figure 3 : Distribution of sources



Location of wells in Nagpur region

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

D. Analytical

Water samples were analysed for routine physical and chemical water quality parameters.Water analyses was carried out by as per standard methods[1] . Presence of phosphorus as ortho phosphate and nitrogen(ammonia, nitrite and nitrate) was checked qualitatively depending on location of a source .

Four parameters were oragno-leptic/ aesthetic and 15 parameters were estimated in laboratory. Three parameters viz. bicarbonates, calcium and magnesium ions (HCO_3^-,Ca^{++} & Mg^{++}) were calculated from stoichiometry. Total dissolved solids were calculated by both gravimetric method and computed from conductivity values in µS multiplied by 0.55 included in published literature[4] since samples were not turbid.

Tables 1a -1d include results of analyses of water samples from tube wells -water. Dug well –water analyses are included in Tables 2a and 2b.

Parameters	Dattatreya Nagar	Sanjuba High School Umred Road	Wadi	Kamptee,	Jaripatka	Market No. 1 Koradi	Shanti Nagar	Manish Nagar	Besa Road, Ravti Nagar	Ranala, Kamptee
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour, Hazen	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	UO	UO	UO	UO	UO	UO	UO	UO	UO	UO
pH	7.8	8.3	8.0	7.5	8.0	7.3	7.6	8.1	7.3	7.0
Conductivity, µS	781	960	785	2375	832	1492	1341	918	1885	2615
Turbidity, NTU	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total dissolved solids, mg/L Gravimetric	532	734	488	1347	544	1087	1230	722	1641	2019
TDS by conductivity factor (0.55) ,mg/L	429	528	432	1306	458	821	378	505	1037	1438
Conductivity factor for sample , (8/9)	0.68	0.76	0.62	0.57	0.65	0.73	0.92	0.79	0.87	0.77
Total alkalinity as $CaCO_3$, mg/L	164	252	132	202	192	222	350	236	424	482
P alkalinity as $CaCO_3$, mg/L	0	0	0	0	0	0	0	0	0	0
MO alkalinity as $CaCO_3$, mg/L	164	252	132	202	192	222	350	236	424	482
Bicarbonates(alk.x 1.22) mg/L as $CaCO_3$	200	307	161	264	234	270	427	288	517	588
Total Hardness as $CaCO_3$, mg/L	306	270	56	900	290	464	242	264	460	860
Ca Hardness as $CaCO_3$, mg/L	190	164	40	672	150	228	136	126	236	520
Mg Hardness as $CaCO_3$, mg/L	116	106	16	228	140	236	106	138	224	340
Calcium as Ca^{++}, mg/L	76	66	16	269	60	91	54	50	94	208
Magnesium as Mg^{++}, mg/L	18	25	4	55	34	57	25	33	54	82
Chloride as Cl^-, mg/L	79	59	95	308	72	292	148	61	64	260
Sulphates as SO_4^{--}, mg/L	41	66	44	157	33	126	137	102	314	401
Total Iron as Fe, mg/L	Nil	Nil	Nil	Nil	Nil	Nil	0.03	Nil	Nil	Nil
Reactive silica as SiO_2, mg/L	14.4	0.17	4.4	1.5	1.8	3.3	7.3	8.4	3.7	2.6
Fluoride, mg/L	0.7	0.8	1.1	0.5	0.8	0.4	0.3	1.2	1.5	0.7
Ammonia,phosphate,mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Ionic strength	8.7	8.9	3.8	25.2	8.8	16.0	10.8	8.8	16.5	27.5
Calculated carbon dioxide ,mg/L as $CaCO_3$	8.2	0	0	14	0	33	17.5	0	64	120

Table 1 a : Water quality- bore wells

Note : 1) CL- Colourless; UO- Unobjectionable, + indicates presence of ammonia and phosphate

Table 1 b : Water quality- bore wells

Parameters	Besa Road	Mhalgi nagar	Burdi	Somalwada	Kashyap Colony	Gandhibag	Vidya nagar,	Jaitala	Manish Nagar	Civil lines,
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour, Hazen	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	UO	UO	UO	UO	UO	UO	UO	UO	UO	UO
pH	7.8	7.8	7.6	7.3	7.8	8.0	8.1	7.7	7.3	7.5
Conductivity, µS	852	899	1076	1384	3055	1085	1209	692	988	683
Turbidity, NTU	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total dissolved solids, mg/L Gravimetric	658	502	882	1132	2825	643	1031	506	708	410
TDS by conductivity factor (0.55) ,mg/L	469	494	592	761	2688	597	665	381	543	376
Conductivity factor 8/9	0.77	0.56	0.82	0.82	0.92	0.59	0.85	0.85	0.72	0.60
Total alkalinity as $CaCO_3$, mg/L	230	184	368	384	330	226	452	208	296	314
P alkalinity as $CaCO_3$, mg/L	0	0	0	0	0	0	0	0	0	0
MO alkalinity as $CaCO_3$, mg/L	230	184	368	384	330	226	452	208	296	314
Bicarbonates(alk. x 1.22) mg/L as $CaCO_3$	281	224	449	468	403	276	551	254	361	383
Total Hardness as $CaCO_3$, mg/L	156	284	342	532	720	236	250	292	246	356
Ca Hardness as $CaCO_3$, mg/L	94	162	116	332	540	140	80	172	142	160
Mg Hardness as $CaCO_3$, mg/L	62	122	176	200	180	96	170	120	104	196
Calcium as Ca^{++}, mg/L	37	65	66	132	216	56	32	69	57	64
Magnesium as Mg^{++}, mg/L	15	29	42	48	43	23	41	29	25	95
Chloride as Cl^-, mg/L	32	75	74	148	606	65	93	33	78	44
Sulphates as SO_4^{--}, mg/L	59	91	36	44	392	25	38	36	105	38
Total Iron as Fe, mg/L	0.3	0.08	Nil	Nil	Nil	0.25	0.13	.09	Nil	0.04
Reactive silica as SiO_2, mg/L	11.9	-	14.2	17.5	24.8	12.9	12.4	10.2	7.9	8.2
Fluoride, mg/L	0.8	0.4	1.0	0.5	0.8	0.4	2.6	0.7	0.6	0.5
Ammonia, phosphate, mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Ionic strength	6.1	9.0	11.7	16.7	28.1	8.0	10.9	8.5	9.4	15.0
Calculated carbon dioxide, mg/L as $CaCO_3$	16	9	18	58	17	0	0	10	44	22

Note: 1) CL- Colourless; UO- Unobjectionable, + indicates presence of ammonia and phosphate

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Table 1 c : Water quality- bore wells

Parameters	Wathoda	Dixit nagar	Kamptee	Kamptee	Sakkardara	Near pond no. 3 Koradi	Near colony ,Koradi	Near canal , Koradi	Koradi	Koradi
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour, Hazen	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	UO	UO	UO	UO	UO	UO	UO	UO	UO	UO
pH	7.0	7.3	7.2	8.0	7.2	8.0	8.1	7.8	7.4	7.9
Conductivity, µS	1232	1047	3690	1645	916	530	742	954	1272	530
Turbidity, NTU	<2	<2	6.8	<1	<1	<2	<2	<2	<2	<2
Total dissolved solids, mg/L Gravimetric	1193	956	2165	987	445	318	445	859	1145	320
TDS by conductivity factor (0.55) ,mg/L	678	576	2029	905	504	292	408	525	700	292
Conductivity factor 8/9	0.97	0.91	0.59	0.6	0.49	0.6	0.6	0.9	0.90	0.6
Total alkalinity as $CaCO_3$, mg/L	320	334	490	152	120	220	340	246	368	330
P alkalinity as $CaCO_3$, mg/L	0	0	0	0	0	0	0	0	0	0
MO alkalinity as $CaCO_3$, mg/L	320	334	490	152	120	220	340	246	368	330
Bicarbonates(alk.x 1.22) mg/L as $CaCO_3$	390	407	598	185	146	264	414	300	449	403
Total Hardness as $CaCO_3$, mg/L	384	424	716	230	238	358	286	560	720	362
Ca Hardness as $CaCO_3$, mg/L	272	200	400	146	180	160	125	332	460	162
Mg Hardness as $CaCO_3$, mg/L	112	224	316	84	58	198	161	228	260	200
Calcium as Ca^{++}, mg/L	109	80	160	58	72	64	50	133	184	65
Magnesium as Mg^{++}, mg/L	27	54	76	20	14	48	38	55	62	48
Chloride as Cl^-, mg/L	194	116	464	251	49	140	37	56	158	65
Sulphates as SO_4^{--}, mg/L	81	110	284	70	68	18	51	70	85	Traces
Total Iron as Fe, mg/L	0.2	0.56	1.3	Nil	Nil	BDL	BDL	BDL	BDL	BDL
Reactive silica as SiO_2, mg/L	3.3	3.8	11.5	9.16	7.8	--	--	--	--	--
Fluoride, mg/L	1.0	0.5	2.8	2.4	4.4	--	--	--	--	--
Ammonia, phosphate, mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	+	+	Nil
Ionic strength	13.4	13.4	26.2	9.7	6.8	11.0	9.2	14.4	19.6	14.8
Calculated carbon dioxide ,mg/L as $CaCO_3$	80	50	74	0	24	0	0	7	26	0

Note: 1) CL- Colourless; UO- Unobjectionable; BDL – Below detectable level, + indicates presence of ammonia and phosphate

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Table 1 d: Water quality- bore wells

Parameters	Dharampeth	Raj Nagar	Subedar Layout	Wanadongri	Wanadongri	Beltarodi	Wardha Road	Bhandra Road,	Hingna Road	Chitaroli
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour, Hazen	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	UO	UO	UO	UO	UO	UO	UO	UO	UO	UO
pH	7.9	7.8	7.4	8.1	8.0	7.9	7.8	7.4	8.5	7.5
Conductivity, µS	1186	898	1125	876	793	1206	938	1594	1177	2375
Turbidity, NTU	<2	<2	<2	<5	1.3	<2	<2	<2	<2	<2
Total dissolved solids, mg/L Gravimetric	748	459	1014	720	616	1063	775	1360	689	1347
TDS by conductivity factor (0.55) ,mg/L	652	494	619	482	436	663	516	877	747	1306
Conductivity factor 8/9	0.63	0.51	0.90	0.82	0.78	0.88	0.83	0.85	0.59	0.57
Total alkalinity as $CaCO_3$, mg/L	286	192	206	126	96	420	314	408	78	202
P alkalinity as $CaCO_3$, mg/L	0	0	0	0	0	0	0	0	06	0
MO alkalinity as $CaCO_3$, mg/L	286	192	206	126	96	420	314	408	72	202
Bicarbonates(alk. x 1.22) mg/L as $CaCO_3$	349	234	251	154	117	512	383	498	88	246
Total Hardness as $CaCO_3$, mg/L	280	232	580	162	44	224	350	184	70	900
Ca Hardness as $CaCO_3$, mg/L	120	192	472	162	36	108	140	132	44	672
Mg Hardness as $CaCO_3$, mg/L	160	40	108	0	8	116	210	52	26	228
Calcium as Ca^{++}, mg/L	48	77	189	65	14	43	56	53	18	269
Magnesium as Mg^{++}, mg/L	38	10	26	0	2	28	50	12	6	55
Chloride as Cl^-, mg/L	68	48	202	222	167	30	70	150	237	308
Sulphates as SO_4^{--}, mg/L	40	24	128	67	72	106	51	177	36	157
Total Iron as Fe, mg/L	0.04	Nil	Nil	0.6	3.6	Nil	0.06	Nil	Nil	Nil
Reactive silica as SiO_2, mg/L	4.6	5	5.8	6.3	6.4	6.4	11.4	10.3	2.4	5.1
Fluoride, mg/L	1.2	1.0	1.1	0.6	1.1	0.7	0.7	1.0	1.3	0.5
Ammonia, phosphate, mg/L	Nil	Nil	+	Nil	Nil	+	Nil	+	Nil	Nil
Ionic strength	9.5	7.3	16.9	7.8	4.5	9.5	11.2	10.6	5.6	25.1
Calculated carbon dioxide, mg/L as $CaCO_3$	0	10	21	0	0	0	16	41	0	14

Note: 1) CL- Colourless; UO- Unobjectionable, + indicates presence of ammonia and phosphate

Parameters	Hingna	Ramdaspeth	Rajnagar	Jawahar Nagar	Hingna	Rameshwari	Bhandara road	Smrutinagar	Dharmpeth	Ramdaspeth
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour, Hazen	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Odour	UO	UO	UO	UO	UO	UO	UO	UO	UO	UO
pH	7.0	7.0	7.8	8.2	7.5	6.7	7.7	7.7	7.3	7.6
Conductivity, µS	1308	894	898	863	789	1585	1495	1264	1520	793
Turbidity, NTU	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total dissolved solids, mg/L Gravimetric	843	648	459	610	668	1170	1253	1125	1318	580
TDS by conductivity factor (0.55) ,mg/L	719	492	494	475	434	872	822	695	695	436
Conductivity factor 8/9	0.64	0.72	0.51	0.71		0.74	0.84	0.89	0.87	0.73
Total alkalinity as $CaCO_3$, mg/L	352	244	192	246	124	314	500	386	400	232
P alkalinity as $CaCO_3$, mg/L	0	0	0	0	0	0	0	0	0	0
MO alkalinity as $CaCO_3$, mg/L	352	244	192	246	124	314	500	386	400	332
Bicarbonates (alk. x 1.22) mg/L as $CaCO_3$	429	297	234	300	151	383	610	471	488	283
Total Hardness as $CaCO_3$, mg/L	352	348	232	102	238	548	286	480	660	328
Ca Hardness as $CaCO_3$, mg/L	174	226	192	64	158	294	216	200	300	230
Mg Hardness as $CaCO_3$, mg/L	178	122	40	38	80	254	70	280	360	98

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Calcium as Ca^{++}, mg/L	17	90	77	26	63	118	86	80	120	92
Magnesium as Mg^{++}, mg/L	43	29	10	9	19	61	17	67	86	24
Chloride as Cl^-, mg/L	82	57	48	29	68	258	86	178	276	80
Sulphate as SO_4^{--}, mg/L	23	47	24	63	33	103	53	121	85	39
Total Iron as Fe, mg/L	Nil	Nil	Nil	0.02	0.4	0.03	Nil	Nil	Nil	Nil
Reactive silica as SiO_2, mg/L	11.4	16	5	9.2	-	6.5	-	5.8	9.6	5.8
Fluoride, mg/L	-	1.3	1.0	1.6	0.2	0.8	0.4	1.6	1.2	0.4
Ammonia, phosphate, mg/L	Nil	Nil	Nil	Nil	Nil	+	+	+	+	+
Ionic strength	9.3	10.3	6.6	5.2	7.0	18.2	12.0	16.5	21.4	10.2
Calculated carbon dioxide ,mg/L as $CaCO_3$	99	61	10	0	7	126	25	19	60	16

Table 2 a : Water quality –dug well

Note: 1) CL- Colourless; UO- Unobjectionable, + indicates presence of ammonia and phosphate

Parameters	Pardi	Amravati Road	Wardha road	Katol Road	Mount road	Dhantoli	Dhantoli	Nandanvan	Sadar	Hingna
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour, Hazen	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	UO	UO	UO	UO	UO	UO	UO	UO	UO	UO
pH	7.4	7.5	7.4	7.1	7.0	7.3	7.4	7.6	7.5	8.0
Conductivity, µS	722	1073	1306	1421	875	1029	452	756	531	1076
Turbidity, NTU	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total dissolved solids, mg/L Gravimetric	403	721	769	917	563	731	400	436	205	840
TDS by conductivity factor (0.55) ,mg/L	397	590	718	782	481	566	249	416	292	592
Conductivity factor 8/9	0.56	0.67	0.59	0.65	0.64	0.71	0.88	0.58	0.39	0.78
Total alkalinity as $CaCO_3$, mg/L	170	302	340	278	232	296	182	164	212	370
P alkalinity as $CaCO_3$, mg/L	0	0	0	0	0	0	0	0	0	0

MO alkalinity as $CaCO_3$, mg/L	170	302	340	278	232	296	182	154	212	370
Bicarbonates(alk.x 1.22) mg/L as $CaCO_3$	207	368	414	339	280	361	222	200	258	451
Total Hardness as $CaCO_3$, mg/L	226	326	216	420	242	280	186	128	168	390
Ca Hardness as $CaCO_3$, mg/L	124	160	104	248	124	156	132	70	96	260
Mg Hardness as $CaCO_3$, mg/L	102	166	112	172	118	124	54	58	72	130
Calcium as Ca^{++}, mg/L	49	64	42	99	50	62	53	28	38	104
Magnesium as Mg^{++}, mg/L	24	40	27	41	28	30	13	14	18	31
Chloride as Cl^-, mg/L	12	58	44	93	25	57	77	50	49	37
Sulphates as SO_4^{--}, mg/L	43	18	34	49	30	4	38	38	13	18
Total Iron as Fe, mg/L	0.03	0.09	0.09	0.11	Nil	Nil	Nil	0.5	0.05	Nil
Reactive silica as SiO_2, mg/L	3.7	3.6	7.1	4.4	8.5	2.2	Traces	5.1	0.4	--
Fluoride, mg/L	0.3	1.0	1.3	0.9	0.4	0.4	0.4	0.9	0.9	--
Ammonia, phosphate, mg/L	Nil	Nil	Nil	+	Nil	+	Nil	Nil	Nil	Nil
Ionic strength	6.2	9.8	7.9	12.1	7.2	8.8	7.1	4.7	5.8	11.4
Calculated carbon dioxide ,mg/L as $CaCO_3$	15	21	24	56	46	36	18	33	15	0

Table 2 b : Water quality dug wells

Note: 1) CL- Colourless; UO- Unobjectionable, + indicates presence of ammonia and phosphat

Table 3 contains averages of parameters and standard deviation both bore and dug well water quality.

Table 3: Average water qualitybore & dug wells

Parameters	Bore wells	Dug wells
pH	7.0 - 8.5	6.7-8.2
Conductivity, µS	1266	1032
Turbidity, NTU	<5	<5
Total dissolved solids, mg/L ,	931± 531	732 ± 308
Total alkalinity as $CaCO_3$, mg/L	272 ± 109	277 ± 95
MO alkalinity as $CaCO_3$, mg/L	272	277
Bicarbonates (T.alk.x 1.22) mg/L as $CaCO_3$	332	337
Total Hardness as $CaCO_3$, mg/L	371± 225	301± 141
Ca Hardness as $CaCO_3$, mg/L	223 ± 165	176 ± 70
Mg Hardness as $CaCO_3$, mg/L	149 ± 83	131± 84
Calcium as Ca^{++}, mg/L	89 ± 66	68 ± 30
Magnesium as Mg^{++}, mg/L	37 ± 32	32 ± 21
Chloride as Cl^-, mg/L	143 ± 125	83 ± 72
Sulphates as SO_4^{--}, mg/L	102 ± 82	44 ± 30
Total Iron as Fe, mg/L	0.52	0.14
Reactive silica as SiO_2, mg/L	7.9	6.6
Fluoride, mg/L	1.2 ± 0.8	0.8 ± 0.4
Carbon dioxide		
Ionic strength from relationship $\mu=\Sigma(m_1z_1^2)/2$ where m_i=molar conc. of ion , z_i= ionic charge	14.24± 6.5	10.73 ± 3.9

II. DISCUSSION

A. Water quality

Comparison of water quality in Tables 1 & 2 with IS 10500 (2012)[2] for drinking water quality indicated that all samples were acceptable for as per their physical and chemical characteristics. Disinfection will be necessary.

B. Total dissolved solids

Total solids in groundwater can be approximated by equation

TDS $=k_eE$ [3] where TDS is expressed in mg/L and EC is the electrical conductivity at room temperature expressed as micro µS/cm K_e is the multiplying factor.

Present study on water quality showed that average multiplying factor for tube and dug wells in Nagpurwere respectively 0.73 and 0.69.

C. Ground water classification

Water, generally is classified based on concentration of TDS. TDS in fresh water is normally less than 500 mg/L. Brackish water dissolved solids vary from 500 to 30,000 mg/L. In saline water TDS exceed 30,000 to 40,000 mg/L.
This study has shown that ground water (both shallow & deep wells) in Nagpur is brackish since average values exceed 700 mg/L.

D. Ionic strength

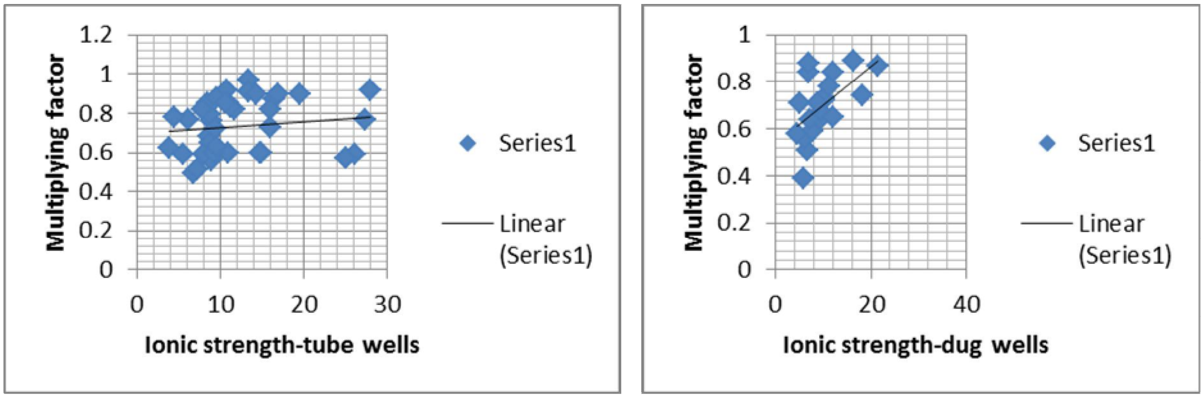
Dissolved solids in ground water are contributed by minerals present in soil and rocks which are in contact with water and also from decaying vegetation, if present. Solutions of various ions in natural watersare "dilute" in normal chemical sense. Ground water can contain metastable concentrations of some ions for a long time. Total concentration of dissolved ions i.e. ionic strength of any water has significance both in domestic and industrial uses because degree and type of scales during water uses depend on ionic concentration/ TDS present in any water.
Ionic strength of each water sample was calculated using the expression$\mu = \Sigma (m_{i.} z_i^2) / 2$[4], where m_i is the molar concentration of a ion and z_i is its charge. Ionic strengths of samples are also included in Tables 1a to1d and 2 a &2b given earlier. Classification of Nagpur bore and dug wells as per ionic strengths are given in Table 4.

Table 4 : Ionic strengths of ground water

Calculated ionic strength	% of bore wells	% of dug wells
<6	5	10
6-8	17.5	35
8-10	30.0	25
10-12	12.5	15
12-14	2.5	--
14-16	12.5	5
16-18	5.0	5
18-20	2.5	--
20-22	2.5	--
22-24	5.0	--
24-26	2.5	5
26-28	2.5	--

Table 4 shows that majority of bore and dug wells have ionic strengths varying between 8& 12. Relatively lower percentage of high ionic concentration in bore wells shows that soluble ions are less in strata where bore wells are located.
Scatter diagramme between multiplying factor and ionic strengths of bore wells and dug wells water is included in Figure 4

Figure 4



E. Environment & ionic strength of water

Ionic strength of ground water in dug and bore wells depends on environment/ location around a well as on geology.In order to specify environmental conditions around tube & dug wells Nagpur city was divided into eight cardinal directions with respect to zero mile stone (Fig.3).

Sources mentioned in Tables 1a to 1d and in 2a to 2b have been classified in **Table 5** as per major activities in the area in which they are located. This table also shows if localities were recent or residential or commercial or near industrial area.

Table 5: Locations, activity & duration of sources vis-a vis ionic strengths

Predominant activity	Number of sources	old/new	Direction	Ionic strength	Average ionic strength
Industrial	13	8/4	N,NE,W	3.8-28.1,	**15.4**
Domestic	22	9/13	NE,SW,S, SE	5.6- 16.6,	**11.1**
Domestic / Commercial	5	5/0	E, SE, W	6.8-25.8	**12.3**

Relatively higher values in industrial area can be due to in advertent wastewater discharges over the ground and subsequent percolation. Proper disposal of non -point waste water discharges from residential colonies is necessary.

F. Saturation index

It is important in case of natural water to verify if there is equilibrium between carbonate minerals when in contact with water. Two saturation indices viz. Langelier and Ryznerof a water are useful and important because they indicate scaling or corrosive properties of water. Langelier index is applicable to a “stationary/stored“ water while Ryzner index is more useful in dynamic systems where water comes across different environment during its use e.g. cooling water systems.

Water is scale forming if Langelier Index is positive and is corrosive if it is negative. Interpretation of Ryzner index of water is as follows[3]

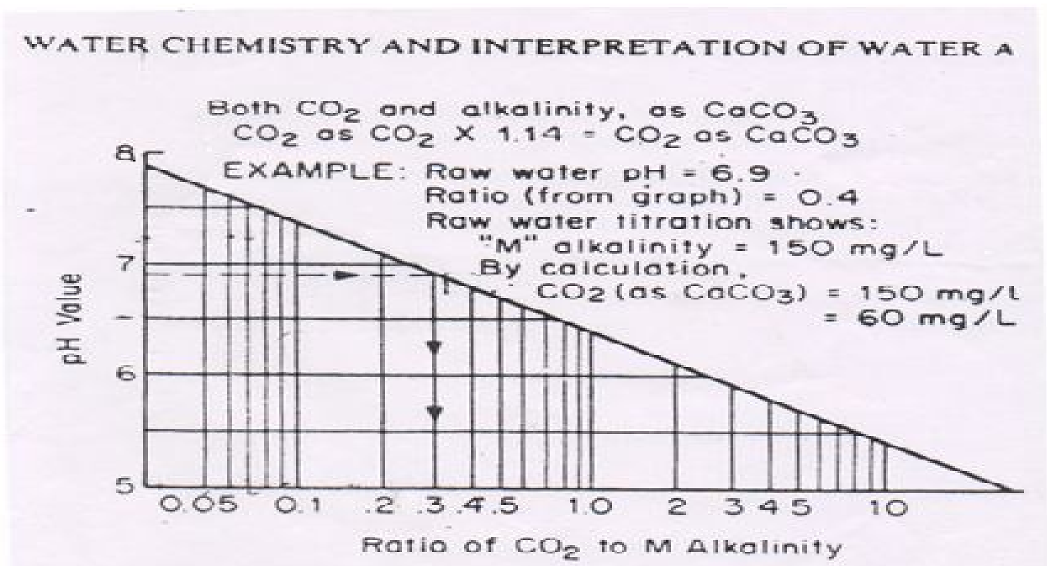
Index	Inference, water can be
4-5	heavy scale forming
5-6	slight scale forming
6-7	in equilibrium
7-7.5	slightly corrosive
>7.5	highly corrosive

Langelier and Ryzner indices for all samples from boreand dug wells were calculated to find if they were in equilibrium or corrosive or scale forming. Percentages of aggressive (corrosive), scale forming and samples in equilibrium with respect to calcium carbonate are given in following table.

Source	In equilibrium %		slightly Corrosive %		Highly corrosive %		Slightly Scale forming %	
	L.I.	R.I.	L.I.	R.I.	L.I.	R.I.	L.I.	R.I
Bore well	5	55	70	22.5	-	12.5	25	10
Dug well	5	30	40	30	-	30	55	10

This table shows that majority (55%) of bore wells samples are in equilibrium as per Ryzner index. About 60 per cent dug well samples were found to be corrosive.One of the reasons for water to be corrosive is the presence of carbon dioxide. Carbon di- oxide can be present in ground water due to natural water systems which include CO_3^{--} , HCO_3^-, OH^- .It can also be present during microbial decomposition of organic matter. Presence of dissolved/free carbon dioxide will make water corrosive. All water samples indicated pH between6.7-8.2. Therefore there was a balance between CO_2 and bicarbonate ions which was measured by pH value. There is approximate relationship between carbon di- oxide, alkalinity and pH value which is shown in following Figure which is reproduced from reference [3].

Figure 5 Approximate relationships of carbon dioxide, alkalinity and pH value.



G. Carbon dioxide

Computed carbon dioxide concentrations in water samples are included in Tables 1a-1d and 2a & 2b. There was no correlation between R.I. and free carbon-di-oxide.

Average carbon di-oxide concentration in bore wells was 18.5 mg/L as $CaCO_3$ and was 34.3 mg/L as $CaCO_3$ in dug wells. Higher carbon dioxide in dug wells is expected because they are accessible to human activities, decay of aquatic growths within wells leading to siltation. Decay at bottom of wells will add to CO_2in water.

Hardness in natural water is due to multivalent cations which in the present case were calcium and magnesium ions. Sixty five to sixty seven per cent ground water samples including those from bore and dug wells showed presence of non- carbonate hardness because total hardness exceeded total alkalinity. Type of hardness is indicative of probable composition of scales. Calcium sulphate scales will be predominant if sulphate is high and such scales are difficult to remove. Location of wells with low sulphate concentration are close to fresh water bodies in Nagpur e.g. bore well near pond no. 3 Koradi. Thirty per cent bore wells showed sulphate beyond 100 mg/L. Average sulphate was 102 ± 82 mg/L for bore and 44 ± 30 mg/L for dug wells. Non carbonate hardness can be also due to chloride ions whose averages and standard deviations are included in Table 3.

Both chloride and sulphate are likely to be contributed to ground water by anthropogenic activities.

H. Probable composition of scales

Natural water is likely to leave residue on after evaporation/during use. Average bore and dug well water quality was used to compute probable chemical composition of residue. Average sodium ion concentrations (by calculation) in these samples were 223 mg/L in bore and 195 mg/L in dug well. It is given below;

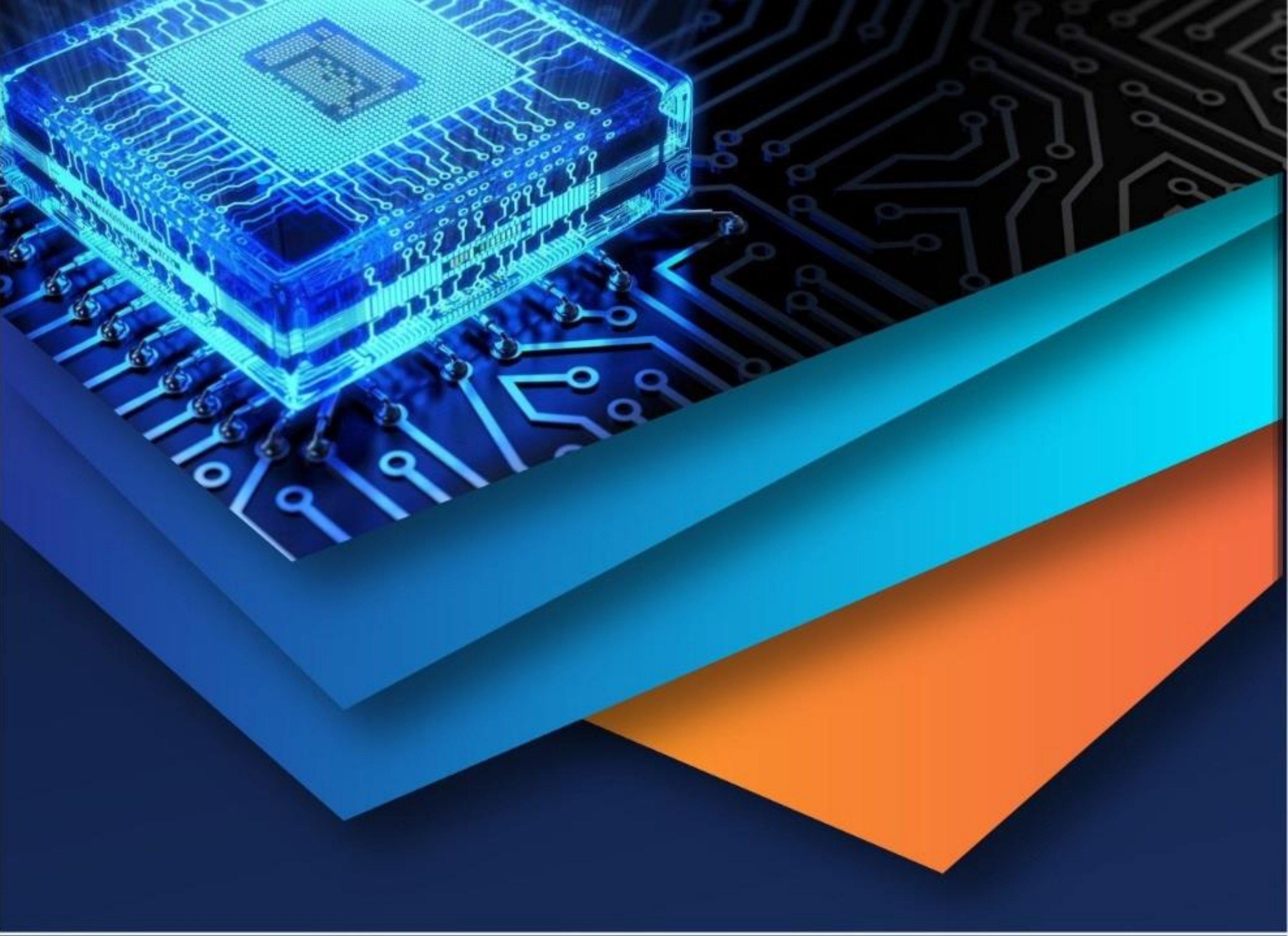
Source	Probable composition of scales mg/L	Total residue, mg/L
Bore well	$CaCO_3$-223; $MgCO_3$-130; Na_2CO_3-186; Na_2SO_4 -236 NaCl-151	926
Dug well	$CaCO_3$-170; $MgCO_3$-112; Na_2CO_3-276 ; Na_2SO_4 -65 NaCl-137	760

III. CONCLUSIONS

A. Ground water within Nagpur city premises is calcium-magnesium bicarbonate type.
B. Calcium and magnesium carbonates will be main contents of scales during use of these sources.
C. Sodium adsorption ratio (SAR) of bore and dug well is less than 3, hence there is no need of restriction on their use for irrigation.
D. Corrosion of plumbing material for domestic use should be expected. Corrosion of pipes drawing water can contribute iron which is undesirable for membrane filters / reverse osmosis units.

REFERENCES

[1] Her Majesty's publication entitled Water & Wastewater Manual, GEMS/Water Operational Guide, by WHO, NEERI publication - Water analysis and wastewater treatment.
[2] Indian standards - Drinking water specification, IS 10500 (2012)
[3] NALCO water handbook-Publisher McGraw-Hill Education.
[4] Geochemistry of water, Calculation and use of ion activity by John D. Hem,



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY