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Physico- Chemical Characteristics of inorganic constituent in Alluvium of Gomti basin and its health effects- A case study from Lucknow and Unnao district, Uttar Pradesh

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ABSTRACT

The alluvial soils of Gomti basin, parts of Lucknow and Unnao districts, Uttar Pradesh show presence of inorganic constituent viz, fluoride varying from 0.2mg/litre to 4.0mg/litre (ppm) in Older Alluvial soil (ultisol) and Newer Alluvial soil (Inceptisols). Besides fluoride, substantial higher concentrations of Nitrate <1.0mg/litre to 246 mg/litre is also observed in the samples. The study is leased on water samples collected from 35 locations in and around of Lucknow and Unnnao. Out of 35 ground water samples 17 samples were collected from urban areas, 16 ground water sample from rural areas and two samples from river water. The present study focused on quality of ground water in rural and urban areas. Geologically the area forms a parts of middle Ganga plain and is covered by alluvial deposits of quaternary age which is composed of older and newer alluvium.

Twenty four physico-chemical parameters namely pH, specific conductance, carbonate, bicarbonate, Chloride, fluoride, Nitrate, Sulphate, Calcium, Magnesium, Sodium, Potassium, Lithium, Boron, Arsenic, Total hardness, Total dissolved solid and heavy metals (Iron, copper, Lead, Zinc, Nickel, Cobalt and Manganese) were analysed and quality deduced in comparison with quality standards of regulatory bodies, world health organization (WHO). Ground water occurs in the pore spaces of unconsolidated alluvial materials in the zone of saturation. The parameters of pH, specific conductance, Total dissolved solid (TDS) and Total hardness as $CaCO_3$ in ground water sample varied from 7.1 to 8.9, 237 to 4500 micromhos/ cm, 220 to 2910mg/litre, 120 to 890gm/litre. The concentration of Ca^{2+}, Mg^{2+} Na^+, K^+, Li^+, B, CO_3^{2-}, HCO_3^-, Cl^-, F^-, NO_3^-, SO_4^{2-} varied from 7.0 to 165 mg/litre, 12 to 140mg/litre, 4.0 to 590 mg/litre, 1.0 to 335 mg/litre, < 0.2mg/lit, < 0.2 to 0.8mg/litre, Nil to 85mg/litre, 75to 675 mg/litre , 10 to 420 mg/litre, 0.2 to 4.0 mg/litre, < 1.0 to 246mg/litre, <2.0 to 1220 mg/litre, respectively. The range of heavy metal concentration are Fe=2.5 to 11.0 mg/litre, As=<0.01 to 0.08mg/litre, Cu= <0.1 to 0.1mg/litre, Pb= 0.1 to 0.7mg/litre, Zn = 0.2 to 5.0 mg/litre Ni=0.01 to 0.09mg/litre, Co=0.03to 0.09 mg/litre and Mn = <0.01 to 0.74 mg/ litre The assessment reveals that ground water have exceeded the desirable limits of WHO for drinking purpose in certain locations.

Keywords: Alluvium, ground water, pollution, water quality.

1. Introduction

Water is most important substance for human existence next to oxygen. Water is life sustenance constituents endowed to our planet to grow and prosper (Girma T, 2005). The fresh water is found in atmosphere as water vapour and in landform as surface and subsurface

water. Ocean forms about 97% of earth surface water occur as saline water not useful for human consumption. The remaining 3% is fresh water. The freshwater in atmosphere constitute 0.02 to 4% water by volume depending on location (Kudesia VP, 1992). Approximately 99.5% of all earths' water is in a form or location unavailable for use leaving on 0.5% of earth water remaining for consumption. Over 90% of the words potable water supply is derived from ground water (Pffaflin JR and Zeigler e.n, 2006). In the last three decades the rapid growth of industrialization and urbanization has caused negative impact on environment. The quantity and quality of available water are very important for the purpose of industries. Each industry has its own water requirements. E.g. for boiler use the water should be soft enough to prevent corrosion and should contain least amount of nitrate and organic matter. Underground water is one of the major water resource for agricultural use.

The Chief mineral like Chloride, Sulphate, bicarbonate, Sodium, Calcium, Magnesium present in the water used for irrigation need careful attention. Sodium, bicarbonate and chloride are three minerals that contribute most to the soil salinity and alkalinity. Plants are most sensitive to saline soils during germination. Irrigation water with poor quality can result in a buildup of salts and high soil pH. Soil acidity affects a plants ability to absorb nutrients.
Increase in population cause negative effect on Sewage disposal, industrial waste, radioactive waste generated. Number of pollutants like fertilizers, pesticides, heavy metals have affected human life by entering into the system directly or indirectly through food chain. Pollution of environment with heavy metals is a serious problem. Heavy metals such as As, Pb, Cd, Hg, Cr, Co, Zn and Se are highly toxic even in minor quantity. Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter human body through food, water, or air. Pollution due to heavy metals is a major concern to ecologist or researchers also because it may contribute significantly to load of metals on natural ecosystem. (Mani V etal, 2005).

Besides causing specific toxicity symptoms, these metals may also contribute to global warming by destroying the atmospheric ozone. Ground water contains soluble natural substances like Arsenic, Fluoride, Nitrate or sulfate which restricts or even prevents its direct use because of health concern. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biological system through contaminated water soil and air. Therefore a better understanding of heavy metal sources their accumulation in the soil and the effect in the water, soil and a plant systems is the important issues of the present day researcher for risk assessment. The present paper deals with the various physico-chemical parameters of ground water of different sources from district Lucknow, Unnao and surrounding areas and discussed their biological effects.

2. Methodology, sample collection and preparation

All samples were collected in the polypropylene bottles of 1 litre capacity. (TORSON made) as prescribed by American Public Health Association APHA (2005) and kept at low temperature. The time between sampling and analysis was tried to be kept at minimum. All samples were collected induplicate, one litre acidified (5 ml 5% HNO_3) and one litre non-acidified. Acidified sample were used for heavy metal analysis (except Arsenic) non acidified for other radicals. All chemical used are laboratory grade (LR) only. pH electrode (pH system -361) was used for measuring pH and conductivity meter -306 was used to measure specific conductance of water sample. Both instruments are a product of Systronics. Unicam Uv-300, Uv-visible spectrometer, a product of thermo electron corporation is used to measure concentration of nitrate. Ion-selective electrode thermo scientific Orion dual star was used to

measure concentration of fluoride in the sample. Flame photometer -128 (Systronics) were used to measure concentration of Lithium, Sodium and Potassium. Heavy metal concentration was determined by Varian AA-240 FS atomic absorption spectrometer. A total of 24 water quality parameters namely pH, specific conductance , CO_3^{2-}, $HC0^-_3$, Cl^- , F^-, NO^-_3, SO_4^{2-} Total hardness as $CaCO_3$, Ca^{2+}, Mg^{2+} Na^+, K^+, Li^+, B, Total dissolved solid, Fe, As Cu, Pb, Zn ,Ni, Co and Mn were determined by following standard analytical methods of APHA –(2005).

In the present study various samples were collected from different urban/ Rural areas of district Lucknow, Unnao and surroundings. The samples were from different ground water sources having different depth. Sample location, source, depth in meters (approximately) and temperature of water sample at the time of collection is given in the following table/map. All samples were collected in the month of September /october-2014.

3. Sample location, source, depth and temperature

Sample location source, depth and temperature are given below (Table -1) and its distribution in Plate -1.

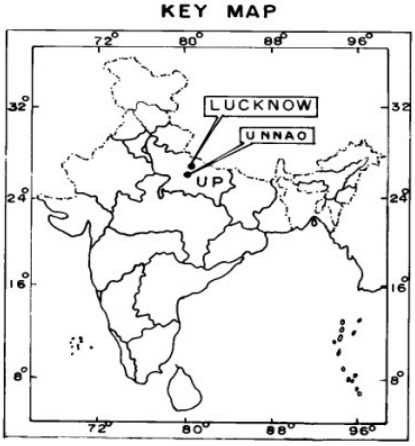

Figure 1: Sample location source, depth and temperature distribution in Plate -1

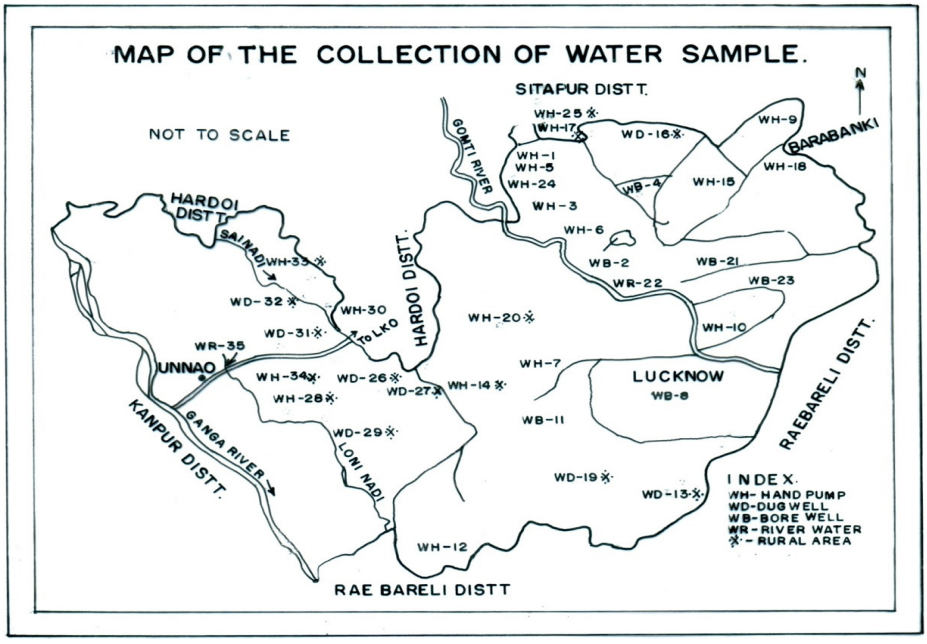

Figure 2: Collection of sample water

Table 1: Lucknow depth and temperature distribution

Sl. No	Location	Source	Depth in metres (Approx)	Temp ^{0}C
1.	WH-1/Jankipuram Sector- I	Hand Pump	10-15	23.4
2.	WB-2/Aliganj, GSI Colony	Bore well	100-200	23.0
3.	WH-3 / Aliganj, Sector –O	Hand Pump	10-15	22.8
4.	WB-4/ Aliganj, Sector –A	Bore well	100-200	23.7
5.	WH-5/ Jankipuram Extension	Hand pump (India mark-II)	30-35	23.2
6.	WH-6/ Tedipulia Sabjimandi	Hand pump (India mark-II)	30-35	24.0
7.	WH-7/ Sadar	Hand Pump	10-15	23.2
8.	WB-8/ Charbag	Bore well	100-200	24.1
9.	WH-9/ Kukrail	Hand Pump	10-15	23.4
10.	WH-10/ Khargapur	Hand Pump	10-15	23.4
11.	WB-11/Alambag Bus station	Bore well	100-200	23.8
12.	WH-12/ Sarojani Nagar	Hand Pump	10-15	22.7
13.	*WD-13/ Nagram	Dug well	10-15	23.2
14.	*WD-14 Narainpur	Dug well	10-15	23.4
15.	WH-15/ Guramba	Hand Pump (India Mark-II)	30-35	23.7
16.	*WD-16/ Itaunja	Dug well	10-15	23.2
17.	*WD-17/ Baksi Ka Talab	Dug well	10-15	23.4
18.	WH-18/ Chinhat	Hand Pump	10-15	23.5
19.	*WD-19/ Mohanlalganj	Dug well	10-15	23.4
20.	*WH-20/ Kakori	Hand Pump (India Mark-II)	30-35	23.2
21.	WB-21/ Indira Nagar	Bore well	100-200	23.7
22.	WR-22 / Gomti Nadi	River	-	24.2
23.	WB-23 / Gomti Nagar	Bore well	100-200	23.6
24.	WH-24/ Chandganj	Hand pump	10-15	23.2
25.	*WH-25 / Ataria	Hand Pump (India Mark-II)	30-35	23.7
UNNAO				
26.	*WD-26 / Bajhera	Dug well	10-15	23.2
27.	*WD-27/ Asoha	Dug well	10-15	23.2
28.	*WH- 28/ Bichia	Hand Pump	10-15	23.4
29.	*WD-29/ Taura	Dug Well	10-15	23.2
30.	*WH -30/ Newalganj	Hand Pump	10-15	23.1
31.	*WD-31 / Makur	Dug Well	10-15	23.3
32.	*WD-32/ Mohan	Dug Well	10-15	23.4
33.	*WH-33/ Dhaura	Hand Pump	10-15	23.2
34.	*WH-34 Nawabganj	Hand Pump (India Mark-II)	10-15	23.6
35.	WR-35/ Loni Nadi	River	-	24.5

*=Rural Area, WH = Hand Pump WD= Dug wells, WB = Bore well, WR = River Water.

3.1 Physico –Chemical Parameters

The analytical results are given in the following table. The maximum recommended value of WHO for potable water is given in small brackets.

Table 2: Physico –Chemical parameters

Sl.No	1	2	3	4	5	6	7	8	9
Sample No	**WH-I**	**WB-2**	**WH-3**	**WB-4**	**WH-5**	**WH-6**	**WH-7**	**WB-8**	**WH-9**
pH at 25^0C	8.3	8.2	7.3	7.3	8.4	8.4	7.4	8.4	7.2
Specific conductance in micromhos/cm at25^0C (WHO =1500 micromhos/cm	930	750	720	1080	740	650	2640	807	2185
$CO3^{2-}$ mg/Litre (ppm)	20	Nil	Nil	Nil	25	7	Nil	30	Nil
$HCO3^-$ mg/Litre	370	425	365	540	350	350	675	210	480
Cl^- mg/Litre (WHO=250mg/litre)	15	12	27	80	15	15	210	130	50
F^{--} mg/Litre (WHO=1.5 mg/litre)	0.5	0.2	0.3	0.4	0.8	0.5	0.3	0.8	0.2
$NO3^-$ mg/Litre (WHO=5.0mg/litre)	3.5	2.3	2.2	4.5	2.3	2.0	210	2.5	3.5
$SO4^{2-}$ mg/Litre (WHO=250mg/litre)	<2.0	<2.0	45	20	20	<2.0	75	25	365
Total Hardness as $CaCo_3$ mg/litre	270	275	310	375	350	275	890	370	725
Ca^{2+} mg/litre (WHO=100 mg/litre)	60	50	70	72	60	65	165	75	155
Mg^{2+} mg/litre (WHO=30 mg/litre)	30	32	35	50	35	30	120	40	80
Na^+ mg/litre (WHO=200 mg/litre)	45	40	35	55	50	30	125	25	50
K^+ mg/litre (WHO=25 mg/litre)	7	5	10	30	10	10	10	10	8
Li $^+$mg/litre	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B mg/litre (WHO=0.5 mg/litre)	0.3	0.6	<0.2	0.3	0.3	0.5	0.8	0.7	<0.2
Total dissolved solid (TDS) at 180^0C mg/litre (WHO=1500 mg/litre)	570	460	445	640	400	450	1470	455	1210
Fe mg/litre (WHO=0.3 mg/litre)	5.0	6.5	5.0	3.5	3.2	6.5	4.7	3.8	7.2
As mg/litre (WHO=0.0 1mg/litre)	0.02	<0.01	0.03	0.03	<0.01	0.03	0.02	<0.01	0.02
Cu mg/litre (WHO=1.2 mg/litre)	<0.1	<0.1	0.1	0.1	<0.1	<0.1	0.1	<0.1	<0.1

Pb mg/litre (WHO=0.1mg/litre)	0.2	0.1	0.2	0.2	0.2	0.1	0.3	0.2	0.1
Zn mg/litre (WHO=3.0 mg/litre)	0.3	0.3	0.6	0.2	0.7	0.8	0.9	0.3	0.5
Ni mg/litre (WHO=0.02mg/litre)	0.02	0.01	0.01	0.01	0.02	0.01	0.04	0.02	0.02
Co mg/litre	<0.03	<0.03	0.04	0.05	0.06	<0.03	0.05	<0.03	0.04
Mn mg/litre (WHO=0.5 mg/litre)	0.11	0.05	0.08	0.02	0.2	0.09	0.09	0.14	0.24

Table 2: Contd…

Sl.No	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Sample No	**WH-I0**	**WB-11**	**WH-12**	***WD-13**	***WD-14**	**WH-15**	***WD-16**	***WD-17**	**WH-18**
pH at 25^0C	7.6	8.2	8.3	8.5	8.4	8.2	8.0	8.2	8.2
Specific conductance in micromhos/cm at25^0C (WHO =1500 micromhos/cm)	360	680	320	2850	915	550	750	650	850
$CO3^{2-}$ mg/Litre (ppm)	NIL	NIL	10	85	50	NIL	NIL	NIL	NIL
$HCO3^-$ mg/Litre	135	380	150	550	385	370	450	430	350
Cl^- mg/Litre (WHO=250mg/litre)	18	10	15	220	52	25	15	15	80
F^{--} mg/Litre (WHO=1.5 mg/litre)	0.2	0.3	0.8	0.6	0.6	2.0	0.6	0.4	0.6
$NO3^-$ mg/Litre (WHO=5.0mg/litre)	2.5	3.5	<1.0	3.5	4	<1.0	1.1	3.5	1.2
$SO4^{2-}$ mg/Litre (WHO=250mg/litre)	<2.0	<2.0	20	70	30	<2.0	6.0	15	45
Total Hardness as $CaCo_3$ mg/litre	165	280	165	385	355	280	160	350	345
Ca^{2+} mg/litre (WHO=100 mg/litre)	35	55	46	30	80	50	30	50	80
Mg^{2+} mg/litre (WHO=30 mg/litre)	20	30	12	50	40	42	25	40	40
Na^+ mg/litre (WHO=200 mg/litre)	8	25	5	150	62	15	80	25	40
K^+ mg/litre (WHO=25 mg/litre)	1	5	2	335	15	2	90	3	5
Li $^+$mg/litre	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B mg/litre (WHO=0.5 mg/litre)	<0.2	<0.2	<0.2	0.3	0.3	0.6	0.7	0.3	0.5
Total dissolved solid (TDS) at 180^0C mg/litre (WHO=1500 mg/litre)	265	350	220	1412	550	340	450	335	520
Fe mg/litre (WHO=0.3 mg/litre)	6.7	2.5	5.5	7.5	11.0	6.8	8.2	5.7	6.2

As mg/litre (WHO=0.0 1mg/litre)	0.03	<0.01	0.01	0.04	0.08	0.02	0.03	0.03	0.01
Cu mg/litre (WHO=1.2 mg/litre)	0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb mg/litre (WHO=0.1mg/litre)	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.3	0.4
Zn mg/litre (WHO=3.0 mg/litre)	0.3	0.5	0.2	1.5	1.1	0.4	0.2	0.4	0.4
Ni mg/litre (WHO=0.02mg/litre)	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02
Co mg/litre	0.03	<0.03	0.05	<0.03	0.07	0.08	<0.03	<0.03	<0.03
Mn mg/litre (WHO=0.5 mg/litre)	<0.01	<0.01	0.03	0.35	0.16	0.26	0.09	0.15	0.09

Table 2: Contd…

Sl.No	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Sample No	***WD-I9**	***WH-20**	**WB-21**	**WR-22**	**WB-23**	**WH-24**	***WH-25**	***WD-26**	***WD-27**
pH at 25^0C	7.8	8.4	7.9	7.1	8.0	7.4	7.6	8.9	8.5
Specific conductance in micromhos/cm at25^0C (WHO =1500 micromhos/cm)	660	950	660	370	237	1278	730	1250	1580
$CO3^{2-}$ mg/Litre (ppm)	NIL	20	NIL	NIL	NIL	NIL	NIL	30	25
$HCO3^-$ mg/Litre	450	215	350	231	170	395	429	250	75
Cl^- mg/Litre (WHO=250mg/litre)	20	175	50	20	35	100	36	135	351
F^- mg/Litre (WHO=1.5 mg/litre)	0.8	1.2	0.4	0.4	0.4	0.2	0.2	0.6	0.3
$NO3^-$ mg/Litre (WHO=5.0mg/litre)	<1.0	<1.0	<1.0	5.0	4.5	246	3.5	2.5	<1.0
$SO4^{2-}$ mg/Litre (WHO=250mg/litre)	<2.0	<2.0	<2.0	405	412	170	12	95	162
Total Hardness as $CaCo_3$ mg/litre	280	420	270	160	120	570	340	265	660
Ca^{2+} mg/litre (WHO=100 mg/litre)	60	85	60	36	24	84	44	25	115
Mg^{2+} mg/litre (WHO=30 mg/litre)	35	50	35	16	14	86	55	50	80

Na^+ mg/litre (WHO=200 mg/litre)	45	35	20	15	4	35	12	108	70
K^+ mg/litre (WHO=25 mg/litre)	3	3	3	6	2	7	5	40	10
Li $^+$mg/litre	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B mg/litre (WHO=0.5 mg/litre)	0.6	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	0.3
Total dissolved solid (TDS) at 180^0C mg/litre (WHO=1500 mg/litre)	430	620	385	505	545	890	430	800	1200
Fe mg/litre (WHO=0.3 mg/litre)	7.5	5.2	3.8	2.8	6.5	6.7	4.4	5.5	5.0
As mg/litre (WHO=0.0 1mg/litre)	0.06	0.03	0.01	0.02	0.02	0.02	0.04	0.03	0.07
Cu mg/litre (WHO=1.2 mg/litre)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Pb mg/litre (WHO=0.1mg/litre)	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.4	0.7
Zn mg/litre (WHO=3.0 mg/litre)	0.9	1.4	0.4	0.4	0.7	0.2	0.7	0.8	0.5
Ni mg/litre (WHO=0.02mg/litre)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03
Co mg/litre	<0.03	0.04	0.03	0.04	<0.03	0.04	0.05	0.07	0.07
Mn mg/litre (WHO=0.5 mg/litre)	0.14	0.33	0.02	0.07	0.12	0.08	0.09	0.06	0.17

Table 2: Contd…

Sl.No	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**
Sample No	***WH-28**	***WD-29**	***WH-30**	***WD-31**	***WD-32**	***WH-33**	***WH-34**	**WR-35**
pH at 25^0C	8.9	8.7	8.7	8.9	8.3	8.5	8.6	8.2
Specific conductance in micromhos/cm at25^0C (WHO =1500 micromhos/cm)	490	4500	860	1505	2805	510	790	910
$CO3^{2-}$ mg/Litre (ppm)	50	30	25	62	15	10	60	NIL
$HCO3^-$ mg/Litre	190	390	150	270	305	280	310	105
Cl^- mg/Litre (WHO=250mg/litre)	20	350	75	105	420	15	50	115
F^{--} mg/Litre (WHO=1.5 mg/litre)	0.2	1.0	0.8	4.0	0.8	0.4	0.8	0.8
$NO3^-$ mg/Litre (WHO=5.0mg/litre)	<1.0	2.5	<1.0	2.5	5.5	<1.0	<1.0	1.1

$SO4^{2-}$ mg/Litre (WHO=250mg/litre)	<2.0	1220	115	220	430	25	20	25
Total Hardness as $CaCo_3$ mg/Litre	215	750	250	205	350	190	260	120
Ca^{2+} mg/litre (WHO=100 mg/litre)	15	70	15	25	27	35	7	60
Mg^{2+} mg/litre (WHO=30 mg/litre)	45	140	50	40	65	28	60	40
Na^{+} mg/litre (WHO=200 mg/litre)	25	590	70	250	410	55	70	105
K^{+} mg/litre (WHO=25 mg/litre)	4	6	2	10	55	3	5	4
Li $^{+}$mg/litre	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B mg/litre (WHO=0.5 mg/litre)	0.4	<0.2	0.2	<0.2	0.4	<0.2	<0.2	<0.2
Total dissolved solid (TDS) at 180^0C mg/litre (WHO=1500 mg/litre)	310	2910	550	995	1800	350	490	445
Fe mg/litre (WHO=0.3 mg/litre)	5.5	8.0	7.0	7.5	6.0	5.0	6.0	5.0
As mg/litre (WHO=0.0 1mg/litre)	0.02	0.05	0.06	0.08	0.05	0.03	0.03	0.01
Cu mg/litre (WHO=1.2 mg/litre)	<0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1
Pb mg/litre (WHO=0.1mg/litre)	0.6	0.6	0.3	0.6	0.3	0.3	0.7	0.1
Zn mg/litre (WHO=3.0 mg/litre)	1.0	5.0	1.9	3.5	2.5	1.5	0.8	0.7
Ni mg/litre (WHO=0.02mg/litre)	0.01	0.02	0.01	0.02	0.03	0.02	0.09	0.04
Co mg/litre	<0.03	0.05	0.03	<0.03	0.07	0.03	0.09	<0.03
Mn mg/litre (WHO=0.5 mg/litre)	0.20	0.30	0.11	0.35	0.59	0.15	0.74	0.38

4. Result and discussion

The summarised account of the various parameters are discussed as follows.

4.1 pH Value

The minimum and maximum allowable pH range for potability is 6.5-8.5 (WHO, 2004). pH depends on temperature. Standard temperature taken here is 25^0C. The role of pH in water chemistry is also associated with the corrosivity, alkalinity, hardness, acidity, chlorination, coagulation and Carbon dioxide stability. Low pH has more effective bactericidal, virucidal

and cysticidal action in disinfection provided by Chlorination. High pH favours the formation of trihalomethanes. pH is ranging from 7.1 to 8.9 in samples analysed.

4.2 Hardness

It represents the total concentration of Calcium and Magnesium ions reported as calcium carbonate. The degree of hardness can be interpreted as (0-50mg/litre) = Soft, (50-150mg/litre) = moderately hard, (150-300mg/litre) = hard, > 300 mg/litre= very hard (John De Zuane P.E, 2013). Many studies in the United States, Canada and Europe have been established in the inverse correlation between hardness and cardiovascular disease (National Academy of Sciences, 1977). The hardness values are ranging from 120-890 mg/litre in the sample analysed.

4.3 Total dissolved solid (TDS)

Total dissolved solids are made up primarily of inorganic salts with small concentration of organic matter. Contributing ions are mainly carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium calcium and magnesium. Major contribution to TDS in water is natural contact with rocks and soils with minor contribution from pollution. The minimum and maximum limit of TDS recommended by WHO is 500-1500 mg/litre. TDS values of all samples except two (sample No-29 & 32) are within the limits recommended by WHO. Sample No-29 and 32 shows TDS Values 2910 mg/litre and 1800 mg/litre respectively

4.4 Specific conductance (WHO=1500 micromhos/cm)

Specific conductance is a measure of the electric current in water samples carried by the ionised substances. The standard unit is micromhos/cm and standard temperature is 25^0C. Raw and potable waters normally register specific conductance from 50-500 micromhos/cm with mineralized water registering values 500-1000 micromhos/cm. It is useful test in raw and finished water for quick determination of minerals. The measured values of specific conductance for all samples except sample No. 7, 9, 13, 29 and 32 are within limits recommended by WHO. Sample no. 7, 9, 13, 29 and 32 shows specific conductance 2640, 2185, 2850, 4500 and 2805 micromhos/cm respectively.

4.5 Bicarbonate

In ground water bicarbonates are derived from carbonate weathering as well as dissolution of carbonic acid in aquifers (Jeevanadam M et.al, 2006). The values are ranging between 75-675 mg/litre in the sample analysed.

4.6 Chloride (WHO =250mg/litre)

Except sample no. 27,29, and 32 the values of Chloride of all the samples analysed are within the limits recommended by WHO. Sample no 27, 29, and 32 shows the chloride value 351, 350 and 420 mg/litre respectively. High values of Chloride in rural areas is because of application of fertilizers, the leaching of which produces Chloride ions. Individuals affected from heart and kidney disease should restrict water consumption with high chloride. High Chloride may lead to laxative effect also (Dahiya S and Kaur A, 1999).

4.7 Fluoride (WHO = 1.5 mg/litre)

The possible source of fluoride in water is mainly geological or anthropogenic (use of phosphatic fertilizers). Fluoride is found in various rocks types such as granite, gneisses quartzites, biotites, muscovites, fluorapatite and fluorite etc. The degree of solubility of these rocks in water depends upon the physico-chemical conditions. The dissociation activity of fluoride will be high in the presence of Sodium and bicarbonate ion in the ground water (Proced.of workshop on Med.Geol.IGCP 454 Nagpur, 2004) (Prasad S and Kar S.K, 2005) (Prasad S and Kar S.K, 2010) (Shukla R and Kar S.K, 2004) (Singh V.P, 2010) (Srivastava A.et.al, 2015). Except sample No 15 and 31 the values of fluoride of all samples are within the limits recommended by WHO. Sample no. 15 and 31 shows fluoride value 2.0 and 4.0mg /litre. Less consumption of fluoride causes dental mottling while more consumption causes fluorosis (Raja Reddy D, 2010).

4.8 Nitrate (WHO =5.0mg/litre)

In the present study the concentration of the nitrates of all samples except two hand pump samples from urban areas (Sample No.7 and 24 =210 and 246 mg/litre respectively) are within permissible limit recommended by WHO. The cause of high values of nitrate in handpump sample may be geogenic in nature (Agrawal GD et.al, 1999) Further higher concentration of nitrates are expected where fertilizers are used, in decayed animals and vegetable matter, in leachates from sludge, refuse disposal and industrial discharges. Nitrates of surface water are used by plants as fertilizers. In humans partial reduction of nitrates to nitrites take place in saliva for all ages and in gastro intestinal tract in infants during the first three months of life (Santro SC, 2008). Toxicity of nitrites is demonstrated by vascodilatory / Cardiovascular effects at high doses and methemoglobinemia at lower doses. Nitrite acts in the blood to oxidise the hemoglobin to methemoglobin which is not an oxygen carrier to the tissues. (Santro SC, 2008) (John De Zuane. P.E, 2013)

4.9 Sulphate (WHO=250 mg/litre)

The values of sulphate concentration except five sample (Sample No.9,22,23,29 and 32 shows 365, 405, 412, 1220 and 430mg/litre respectively) are within the limits recommended by WHO. No adverse health effect is recorded when concentration of sulphate is less than 500mg/litre. High concentration causes Diarrhoea and dehydration (Durrani A, 2012).

4.10 Boron (WHO =0.5mg/litre)

The values of Boron are ranging from > 0.2 to 0.8mg/litre in the samples analysed. The national academy of science, institute of medicine categorizes Boron as possible trace mineral nutrient for human. Boron is essential for plant growth also. Deficiency studies in animals and humans have provided some evidence that low intakes of Boron affect cellular function and activity of other nutrients. It may interact with vitamin D and Calcium, influence estrogen metabolism and play a role in Cognitive function (U.S.Envir.prot.agency, 2008).

4.11 Lithium (No WHO recommendation) Sodium (WHO=200 mg/litre) and Potassium (WHO =25mg/litre)

Biological function of lithium is not yet known. Sodium is considered harmful in drinking water at high concentrations to persons suffering from cardiac renal and circulatory diseases (Calabrese E.J and Tuphill RW, 1980). Potassium is an essential nutritional element for

humans, animals and plants. It is non- toxic but acts as a cathartic in excessive concentration. Various biological functions are influenced positively by potassium. The values of Lithium, Sodium (Except sample No. 29, 31 and 32 shows 590, 250 and 410 mg/litre respectively) and Potassium (Except sample No. 4, 13, 16, 26 and 32 shows 30,335, 90, 40 and 55 mg/litre respectively) are within permissible limit recommended by WHO.

4.12 Arsenic (WHO =0.01mg/litre)

Atomic absorption spectrometer coupled with hydride generator is used for analysis of Arsenic in collected non-acidified water sample. Lower limit of detection for Arsenic by this process is 0.005 mg/litre. Geogenic factors contribute Arsenic in the sample. Trivalent Arsenic compounds are most toxic. The International Agency for Research on Cancer (IARC) classified Arsenic of questionable carcinogenicity in animals and sufficient evidence that inorganic Arsenic compounds (Arsenate and Arsenite) are skin and lung carcinogens in humans (John De Zuane. P.E, 2013). The values of Arsenic are ranging from 0.01 mg/litre to 0.08 mg/litre for samples analysed.

4.13 Heavy metals

(John De Zuane. P.E, 2013) *Copper (WHO=1.2 mg/litre):-* Copper is considered as an essential element for human nutrition because it is required in many enzymatic reactions. More intake of copper causes symptoms of gastroenteritis with nausea. The values of copper observed in the samples analysed is <0.1 to 0.1 mg/litre. *Zinc (WHO =3.0 mg/litre):-* National Academy of Science (NAS) consider Zinc an essential element in human and animal nutrition. Daily consumption of Zinc recommended by WHO is 4-10 mg/day depending upon age and sex. Concentration of zinc are ranging from 0.2 to 5.0 mg/litre in the samples analysed. *Lead (WHO = 0.1 mg/litre):-* Lead is not an essential nutritional element. It is accumulative poison to humans.

Typical symptoms of advanced Lead poisoning are constipation, anemia, gastrointestinal disturbances, tenderness and gradual paralysis in the muscles, specifically of arms. Lead values are ranging from 0.1 to 0.7 mg/litre. *Nickel (WHO = 0.02 mg/litre) and Cobalt (No WHO recommendation)*:- Both are essential element for living being. Cobalt is a component of vitamin B-12. The values of Nickel are ranging from 0.01 to 0.09 mg/litre and for Cobalt is 0.03 to 0.09 mg/litre. *Iron (WHO = 0.3 mg/litre)*:- Iron is an essential element for plants and animals. Iron deficiency causes anemia. Values of Iron are ranging from 2.5 to 11.0 mg/litre in the sample analysed. *Manganese (WHO = 0.5 mg/litre):-* Manganese has been judged as one of the least toxic element. Values of Manganese are ranging from <0.01 to 0.74 mg/litre.

5. Conclusion

The values of ground water quality parameters when compared with respective recommended standards (WHO) it is observed that for most of the sample the values of pH, specific conductance, HCO_3^-, F^-, NO_3^-, SO_4^{2-} Ca^{2+}, Mg^{2+} Na^+, K^+ B and total dissolved solid (TDS) are within desirable limits but moving towards higher side. Samples collected from dug well of rural areas are showing high values of specific conductance, TDS, SO_4^{2-} Na^+ and Cl^- than from hand pump samples may be because of the use of fertilizers, the leachates of which

percolates through the soil and contaminates ground water, In urban areas the main contaminants are sewage water and industrial discharges. The values of Arsenic of dugwell samples are also more than the hand pump samples and exceeds than the recommended standard value of WHO. Heavy metals like Fe, Cu, Zn, Ni, Mn, Co are important for optimum functioning of biological system and their deficiency or excess could lead to a number of disorders. The values of Cu, Ni, Zn and Mn are within limits while values of Fe and Pb are more than the limits of recommended standard value of WHO. All above results observed suggests that rapid growth of industrialization, urbanization has created negative impact on environment. The study suggests that ground water quality of city Lucknow, Unnao and surroundings is slowly degrading and near future the ground water resource will feared to be polluted and unfit for potability and other purposes if appropriate strategies are not adopted forth with.

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