

Study of Correlation of Drinking Water in Indore City (M.P.)

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Abstract: *In the present study, various drinking water samples have been studied in Southern Indore city of (M.P.). Water samples have collected from various water sources namely tap water, boring water, well and hand pump. Water samples were analyzed for various water quality parameters like pH, electrical conductance, total dissolved solids, total alkalinity, total hardness, chloride, sulphate, nitrate, fluoride, sodium, potassium, mercury, iron, copper, zinc, lead and cadmium. In the present study 23.33%, 25%, 28.33% samples of total hardness were cross the standard permissible limits as (300mg/l) during rainy, winter and summer seasons. Only 81.25%, 84.37% and 84.37% of drinking water samples for TDS crossed the permissible limit as 500 mg/l (BIS, 1998) in Rainy, winter and summer seasons respectively. In the present study the values of fluoride, nitrate and sulphate found were under the permissible limit in all the drinking water samples. None of the water samples crossed the permissible limit for heavy metals namely Copper, Cadmium, Mercury and Lead except Zinc. Pearson's correlation coefficient (r) values among various water quality parameters of all the samples were computed.*

Keywords: Drinking water analysis, parameters, Heavy metals, urban areas and correlation

1. Introduction

Indore is regarded as the commercial capital of the Indian state of Madhya Pradesh. It is the largest city of the state, Located on the Malwa Plateau, it lies just north of the Vindhya Mountain Range. With increasing pollution, many water quality parameters were affected so values of various drinking water samples crossed the standard permissible limits. At many places the pipeline of municipal tap water supply crossed the sewage water which causes water borne diseases, such as diarrhoea, cholera, jaundice, typhoid and dysentery. Contamination of ground water resources may transmit various types of diseases like cholera, typhoid, dysentery and diarrhoea. Due to increasing human Population, the water quality is deteriorating everywhere. Urbanization and Industrialization have adversely affected quality of drinking water. The presence of heavy metals in drinking water is of great concern because of their toxicity and threat to human life and also to Environment.

2. Material and Methods

Drinking water analyzed physically and chemically by Standard method of water and waste water (APHA, 1985) and practical methods for water pollution studies (Trivedy *et al.*, 1986). pH, electrical conductivity and total dissolved solids were measured by pH meter, conductivity meter and TDS meter respectively. The concentration of Na and K were estimated by flame photometer. Spectrophotometer was used to determine by concentration of sulphate, nitrate, fluoride, iron and mercury. The concentration of zinc, lead and cadmium were estimated by Atomic Absorption Spectrophotometer.

3. Result and Discussions

In the present study, Pearson's correlation coefficient (r) of all the drinking water samples were computed among various water quality parameters. The significance

correlation coefficient values are reported in the table -1, 2 and 3.

Total dissolved solids showed highest positive correlation with electrical conductivity (0.99, 0.98, and 0.91), total hardness (0.86, 0.87, and 0.81), Calcium hardness (0.83, 0.79, and 0.71), Magnesium hardness (0.57, 0.80, and 0.80), total alkalinity (0.84, 0.61, and 0.58) during rainy winter, summer seasons respectively. It is indicated that Total dissolved solids and electrical conductivity in the drinking water is mainly due to hardness and alkalinity by salt of calcium, salt of magnesium.

The value of Conductivity recorded range from 142 μ mhos/cm to 1769 μ mhos/cm and 230 μ mhos/cm to 1807 μ mhos/cm and 250 μ mhos/cm to 1811 μ mhos/cm and TDS ranged from 128 mg/l to 1011 mg/l, 131 mg/l to 1288 mg/l and 137 mg/l to 1100 mg/l in rainy, winter and summer seasons respectively. Electric conductivity showed highest positive correlation with total hardness (0.87, 0.87, and 0.83). Calcium hardness (0.84, 0.80, 0.74), alkalinity (0.84, 0.64, 0.63), Chloride (0.71, 0.75, 0.72), Sodium (0.78, 0.72, 0.69) and bicarbonate (0.84, 0.64, 0.63) during rainy, winter and summer seasons respectively.

The value of Total hardness recorded range from 20 mg/l to 630 mg/l and 50 mg/l to 660 mg/l and 100 mg/l to 690 mg/l, Calcium ranged from 10 mg/l to 160 mg/l and 25 mg/l to 200 mg/l and 30 mg/l to 150 mg/l and magnesium ranged from 7.3 mg/l to 114 mg/l and 13 mg/l to 111 mg/l and 15 mg/l to 135 mg/l in rainy winter and summer seasons respectively. Total hardness showed highest positive correlation with calcium (0.94, 0.87, and 0.84), magnesium hardness (0.59, 0.95, and 0.95), total alkalinity (0.80, 0.61, and 0.56), bicarbonate (0.90, 0.67, and 0.56), and chloride (0.82, 0.78, and 0.80), during rainy, winter and summer season respectively. It is indicated that total hardness in the drinking water is mainly due to hardness and alkalinity by salt of calcium, salt of magnesium, salt of chloride and bicarbonate.

Calcium hardness showed highest positive correlation with magnesium hardness (0.89, 0.80, and 0.80), total Hardness (0.97, 0.87, and 0.84), chloride (0.80, 0.73, and 0.63), and sodium (0.81, 0.76, and 0.75) during rainy, winter and summer season respectively. Magnesium hardness showed highest positive correlation with Total hardness (0.94, 0.94, 0.80), chloride (0.80, 0.79, 0.79), sulphate (0.60, 0.60, 0.62), and sodium (0.75, 0.75, 0.76) during rainy, winter and summer season respectively.

The value of Chlorides found range from 15 mg/l to 07 mg/l and 36 mg/l to 500 mg/l and 40 mg/l to 500 mg/l and the value of Sodium ranged from 6 mg/l to 102 mg/l and 8 mg/l to 110 mg/l and 5 mg/l to 105 mg/l, in rainy, winter and summer seasons respectively. Chloride showed positive correlation with Total dissolved solids (0.78, 0.79, 0.69), conductivity (0.79, 0.75, 0.72), bicarbonate (0.76, 0.59, 0.57), calcium hardness (0.80, 0.73, 0.63), magnesium (0.79, 0.79, 0.80), total hardness (0.82, 0.79, 0.78), sodium (0.81, 0.76, 0.73) in rainy, winter and summer season respectively. Salt of Sodium and combination of chloride is mainly responsible for the TDS. Sodium showed highest positive correlation with TDS (0.77, 0.73, and 0.69), electrical conductivity (0.78, 0.72, and 0.69), total hardness (0.82, 0.78, and 0.80), Calcium hardness (0.81, 0.76, and 0.75), Magnesium hardness (0.75, 0.75, and 0.76), and total alkalinity (0.77, 0.64, and 0.60) during rainy, winter and summer seasons respectively.

The value of Nitrates observed range from 0.021 mg/l to 1.99 mg/l and 0.01 to 2 mg/l and 0.01 mg/l to 1.39 mg/l and the value of Sulphate ranged from 1.22 mg/l to 29.18 mg/l and 1 mg/l to 40 mg/l and 1 mg/l to 50 mg/l, in rainy, winter and summer seasons respectively.

In the present study all samples of sulphate, Nitrate and Fluoride were under the standard permissible limits as (200 mg/l) (BIS, 1998), (45mg/l) (BIS, 1998) and (1.5 mg/l) (WHO, 2004) respectively during rainy, winter and summer seasons. In the present study none of water samples crossed the standard permissible limit for heavy metals namely Iron (0.3 mg/l) (WHO, 2004), Zinc (0.5 mg/l) (WHO, 2004), Lead (0.05 mg/l) (WHO, 2004), Cadmium (0.01 mg/l) (BIS, 1998) and Mercury (0.001 mg/l) (WHO, 2004) respectively during rainy, winter and summer seasons.

Water source is mostly contaminated due to either its location near the sewage line or waste water which stands around the source. Seepage from sewage line also contributes to bacterial contamination. At many places the pipeline of municipal tap water supply crossed the sewage water which causes water borne diseases, such as diarrhoea, cholera, jaundice, typhoid and dysentery. On the basis of above study, it is recommended that the drinking water in the study area should be treated before it is used for drinking and other domestic purposes.

References

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Table 1: Correlation Coefficient (r) of drinking water quality of South Indore City in the rainy season

	pH	TDS	EC	HCO ₃	TA	Ca	Mg	TH	CL	SO ₄	NO ₃	F	Na	K	Hg	Fe	Cu	Zn	Pb	Cd
pH	1	-0.54	-0.54	-0.37	-0.4	0.4	-0.48	-0.4	-0.37	-0.3	-0.32	-0.03	-0.44	-0.23	0.04	-0.1	-0.02	-0.01	-0.17	-0.34
Total Dissolve solids		1	0.99	0.84	0.84	0.83	0.57	0.86	0.78	0.6	0.44	0.46	0.77	0.08	0.32	0.35	0.28	0.28	0.24	0.09
Electrical Conductivity			1	0.84	0.84	0.84	0.79	0.87	0.79	0.6	0.42	0.46	0.78	0.1	0.32	0.35	0.29	0.28	0.24	0.1
Bicarbonate				1	0.99	0.81	0.77	0.8	0.76	0.6	0.3	0.53	0.77	-0.03	0.5	0.28	0.34	0.32	0.25	0.22
Total Alkalinity					1	0.81	0.77	0.8	0.76	0.6	0.3	0.53	0.77	-0.03	0.5	0.28	0.34	0.32	0.25	0.22
Calcium Hardness						1	0.89	0.97	0.8	0.6	0.34	0.46	0.81	0.12	0.49	0.36	0.37	0.28	0.43	0.15
Magnesium Hardness							1	0.94	0.79	0.6	0.43	0.26	0.75	0.18	0.4	0.55	0.31	0.22	0.23	0.14
Total Hardness								1	0.82	0.6	0.36	0.44	0.82	0.16	0.47	0.44	0.38	0.28	0.37	0.14
Chloride									1	0.4	0.48	0.49	0.8	0.2	0.38	0.3	0.32	0.33	0.25	0.15
Sulphate										1	0.26	0.34	0.48	-0.00	0.35	0.4	0.13	0.23	0.09	-0.02
Nitrate											1	-0.04	0.27	0.15	-0.06	0.4	0.05	0.09	-0.01	0.01
Fluoride												1	0.6	-0.04	0.48	0.04	0.36	0.35	0.47	0.19
Sodium													1	0.19	0.49	0.24	0.45	0.32	0.87	0.18
Phosphate														1	-0.01	-0.1	0.08	-0.05	0.05	-0.08
Mercury															1	0.15	0.38	0.37	0.37	0.2
Iron																1	0.09	-0.01	-0.02	0.18
Copper																	1	0.29	0.18	0.14
Zinc																		1	0.09	0.24
Lead																			1	0.007
Cadmium																				1

Table 2: Correlation Coefficient (r) of drinking water quality of South Indore City in the winter season

	pH	TDS	EC	HCO ₃	TA	Ca	Mg	TH	CL	SO ₄	NO ₃	F	Na	K	Hg	Fe	Cu	Zn	Pb	Cd
pH	1	-0.24	-0.23	-0.26	-0.3	-0.26	0.21	-0.2	-0.21	.08	-0.07	-0.03	-0.15	-0.15	0.12	-0.3	0.1	-0.04	-0.17	0.01
Total Dissolve solids		1	0.98	0.61	0.61	0.79	0.80	0.87	0.79	0.5	0.45	0.2	0.73	-0.06	0.25	0.22	0.11	0.2	-0.03	0.14
Electrical Conductivity			1	0.64	0.64	0.8	0.79	0.87	0.75	0.5	0.42	0.24	0.72	-0.06	0.26	0.21	0.12	0.16	-0.01	0.15
Bicarbonate				1	1	0.54	0.95	0.61	0.59	0.4	0.16	0.21	0.64	0.05	0.15	0.1	0.2	0.3	-0.06	0.17
Total Alkalinity					1	0.54	0.48	0.61	0.59	0.4	0.16	0.21	0.64	0.05	0.15	0.1	0.2	0.3	-0.06	0.17
Calcium Hardness						1	0.80	0.87	0.73	0.4	0.42	0.45	0.76	-0.03	0.36	0.14	0.02	0.28	0.13	0.03
Magnesium Hardness							1	0.94	0.79	0.6	0.43	0.26	0.75	0.18	0.4	0.55	0.31	0.22	0.23	0.14
Total Hardness								1	0.79	0.5	0.4	0.23	0.78	-0.1	0.34	0.3	0.21	0.15	0.11	0.14
Chloride									1	0.3	0.53	0.23	0.78	-0.04	0.28	0.46	0.14	0.13	-0.05	0.22
Sulphate										1	0.14	0.07	0.34	-0.09	0.06	0.16	0.06	0.09	0.037	-0.1
Nitrate											1	-0.23	0.32	0.04	0.39	0.35	0.26	0.14	-0.3	0.05
Fluoride												1	0.44	-0.18	0.19	-0.1	0.2	-0.06	0.14	0.12
Sodium													1	0.22	0.26	0.14	0.23	0.3	0.09	0.18
Phosphate														1	-0.13	-0	0.03	0.25	0.04	0.14
Mercury															1	0.03	0.07	0.22	-0.06	0.26
Iron																1	0.02	-0.24	0.08	0.2
Copper																	1	0.11	-0.23	0.23
Zinc																		1	-0.06	0.14
Lead																			1	-0.01
Cadmium																				1

Table 3: Correlation Coefficient (r) of drinking water quality of South Indore City in the summer season

	pH	TDS	EC	HCO ₃	TA	Ca	Mg	TH	CL	SO ₄	NO ₃	F	Na	K	Hg	Fe	Cu	Zn	Pb	Cd
pH	1	-0.25	-0.18	-0.15	-0.2	-0.06	0.21	-0.2	-0.15	-0.1	-0.07	0.05	-0.16	-0.29	0.2	-0.2	0.08	-0.03	0.04	0.03
Total Dissolve solids		1	0.91	0.58	0.58	0.71	0.80	0.81	0.69	0.6	0.21	0.33	0.69	0.03	-0.02	0.21	0.15	0.22	0.07	-0.12
Electrical Conductivity			1	0.63	0.63	0.74	0.79	0.83	0.72	0.5	0.25	0.42	0.69	0.05	0.01	0.2	0.16	0.22	-0.01	-0.07
Bicarbonate				1	1	0.43	0.95	0.56	0.57	0.4	0.22	0.36	0.6	-0.15	-0.03	0.06	0.02	0.32	0.08	0.17
Total Alkalinity					1	0.43	0.48	0.56	0.57	0.4	0.22	0.36	0.6	-0.15	-0.03	0.06	0.02	0.32	0.08	0.17
Calcium Hardness						1	0.80	0.84	0.63	0.4	0.29	0.45	0.75	-0.06	0.09	0.02	0.22	0.25	0.07	0.03
Magnesium Hardness							1	0.94	0.80	0.62	0.43	0.26	0.76	0.18	0.4	0.55	0.31	0.22	0.23	0.14
Total Hardness								1	0.78	0.5	0.31	0.38	0.8	-0.08	-0.01	0.21	0.22	0.16	0.02	-0.08
Chloride									1	0.3	0.39	0.48	0.73	-0.07	0.05	0.36	0.11	0.19	-0.02	-0.02
Sulphate										1	0.07	0.11	0.28	-0.09	-0.17	0.09	0.1	0.11	0.3	-0.08
Nitrate											1	-0.07	0.19	-0.1	0.13	0.19	-0.39	0.02	-0.23	0.02
Fluoride												1	0.59	-0.24	0.1	-0	0.49	0.09	0.19	-0.07
Sodium													1	0.1	0.06	0.09	0.35	0.46	0.04	0.01
Phosphate														1	0.08	0.18	-0.12	-0.62	-0.19	-0.1
Mercury															1	-0	-0.04	0.04	-0.18	-0.02
Iron																1	-0.03	-0.16	-0.11	0.01
Copper																	1	0.1	0.05	-0.07
Zinc																		1	-0.02	-0.11
Lead																			1	0.02
Cadmium																				1