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Assessment of Quality Drinking Water in Gimbi Town, West Wollega

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Abstract: Analysis of Drinking water sample was carried out to develop a data base on the quality of water being consumed in different sites of Gimbi town. Composite Drinking water samples, total of 20x3 = 60 were collected from five sites of the town. Preservation of water samples were done by adding 2 drops of concentrated HNO_3 and 1 ml of 10 % NaOH prior to sampling to each water sample for heavy metal and Phenol analysis respectively before storage below 4 °C until analyzed. The samples were digested using HNO_3 for heavy metal analysis. Water samples were distilled using simple distillation and distillate was collected for Phenol analysis. Parameters Temperature, Conductivity, Total dissolved solids (TDS), pH, and Heavy metals, Cr (VI), Cu (II), Cd (II); Pb (II), Zn (II), and Phenol were analyzed using AAS and UV-Vis Spectrophotometer. All samples contain Lead (II), Cadmium (II), Chromium (VI), Copper (II), Zinc (II) and Phenol, within acceptable limits recommended by WHO. The concentration of Metal ions and Phenol in the analyzed water samples are found in the Range: Lead (II) (0.34 μg/l - 0.78 μg/l), Chromium (VI) (0.3 μg/l - 0.52 μg/l), Cadmium (II) (0.3 μg/l - 0.62 μg/l), Copper (II) (0.32 μg/l - 0.97 μg/l), Zinc (II) (0.31 μg/l - 0.92 μg/l) and Phenol (0.3 μg/l – 0.99 μg/l).

Keywords: Heavy Metal Ions, Phenol, Analysis, Atomic Absorption Spectrometry, UV-Visible Spectrophotometry

1. Introduction

Environmental pollution is a major global problem posing serious risk to human and living organism. The development of Modern Technology and rapid Industrialization are among the foremost factors for Environmental pollution. The Environmental pollutants are spread through different channels. Pollution of the Environment has significant impact on living Organisms. Heavy metals, toxicity is one of the major current Environmental health problems because of bioaccumulation through the food chain. Water pollution is the contamination of water bodies (e.g. Lakes, Rivers, Oceans and Ground waters). Water pollution occurs when pollutants Heavy metals and Phenol are discharged directly or indirectly into the water bodies. The contaminants, metals like Pb, Cd, Cu, Cr, and Zn are known to show effect on human body [1]. The presence of Heavy metals in water degrade their quality which affect Human health and Organism. Even the essential metals at higher concentration are toxic. Water is one of the most essential component of life on earth. In its purest form it is odour less, colourless and tasteless but due to human activities, it is usually contaminated with solid wastes, effluents from Chemical Industries and dissolved Gases. Over decades Surface and Ground water got polluted drastically due to increased Human activities. The quality of water is a vital concern for Mankind, since it is directly linked with Human welfare. Human activities influences Surface and Ground water quality reflects not only discharge of waste, but also include contaminated surface runoff [2]. The quality of Surface and Ground water are commonly affected by waste disposal and land use. The waste may occur as individual mounds, or it may be spread over the land. Cause of water contamination is the disposal of waste materials directly on the land surface. High pollution levels of Rivers and Groundwater had led to different Environmental consequences, such as a reduction in biodiversity, increase in water related diseases and the decrease in agricultural productivity. The extent of enteric diseases in different areas depends upon the extent to which certain water is exposed to contamination. Surface water, Groundwater, Drinking water and Raw water in general can get polluted by different factors which results in the

deterioration of drinking water. Water polluted with Heavy metal are a problem associated with areas of intensive Industry. However, Road ways, areas of Dumpsites and Automobiles now are considered to be sources of Heavy metals. Even though important to Mankind exposure to them during production, usage and their discharge in to the Environment can cause hazards to Man, other Organisms and the Environment. Different Heavy metals used by Man are maintained to exhibit toxic effects on lives. Over decades there has been increasing global concern over the public health impacts attributed to Environmental pollution. Improper management of solid waste is one of the main causes of Environmental pollution and degradation in many Cities, especially in Developing Countries. Generally, salt, salinity, sea water intrusion, lateral migration, vertical seepage, hazardous waste disposal sites, underground storage tanks, urban storm water runoff, mine drainage, wells and oil-field brines are the major sources of Heavy metals for Surface and Ground water contamination.

The importance of Ground and Surface water for the existence of Human society not be over emphasized. Physico-Chemical parameter: P^H, conductivity, temperature, and total dissolved solids are important to know water condition and concentration of Heavy metals and Phenol are determined using AAS and UV-vis Spectrophotometry. The quality of Surface water, Ground water and Drinking water has been assessed comparing with the standard desirable limit World Health Organization (WHO). Gimbi is blessed with adequate Drinking water sources, but Groundwater and Surface water are rare, rapid population growth, and Urbanization placed immense stress on the quality as well as the quantity of water resources in the city. Ground and Surface water quality is important to Human health, Agri-culture, Aquaculture and Industry. Water is mainly polluted with Inorganics, Organics, Sediments, Radioactive Materials and Heavy metals. The main sources of water contamination are Industrialization, Civilization, Agricultural activities and other Environmental and Global changes. Ground water and Surface water resources are among the most important Environmental issues due to pollution, Heavy metals and other pollutants [3].

Heavy metal contamination has become a significant problem in several Community and Agricultural area due to the application of Commercial Agrochemicals on Agricultural production, Industrial processes, Mining, inproper disposal of waste contaminate natural water. Heavy metals can eventually dispersed and accumulated in the soil as well as surface and groundwater and may therefore cause adverse impact on Human health effect to living Organisms. Heavy metals can discharged into the Environment through Mining, Agrochemicals, Textile, Tannery, disposal of waste from garage area which easily mixed with natural water by erosion; in proper disposal of waste from home contaminate natural waters [4]. Modern civilization, poor planning, rapid population growth & Industrial development utilize enormous amount of chemicals. This can lead the introduction of contaminants into water bodies. The contamination of water by toxic Heavy metals are a worldwide Environmental problem [5]. The most common heavy metals are Cr, Cd, Pb, Cu, and Zn. In fact, Heavy metals are toxic to Aquatic flora, Animals and Human beings even at relatively low concentrations [6]. Organic compounds can be considered as water pollutants if their concentration exceeds allowed level in drinking water. Common Organic pollutants are Phenol and its derivatives, pesticides, hydrocarbon, detergents, oils, greases, pharmaceuticals, proteins, and carbohydrates. Phenol and its derivatives are important compounds since they are widely used for the commercial production of a wide variety of resins; phenolic resins which is an automobile manufacturing material and appliances, epoxy resins and adhesives, and polyamide for various applications. Phenol is essential as well as has disadvantages due to its toxicity nature. Water containing Phenol (toxicity nature) is characterized as bad odour and taste which causes Vomiting and nausea, increased respiratory rate, Anorexia, liver and kidney damage, and headache. The analysis of the natural water for physical, chemical properties including trace element contents are very important for public health studies [7].

In this study Drinking, Ground and Surface water quality, water type and sources of contaminants have been studied. Study Socially acceptable and economically feasible methods of removing the pollutant are essential for safety assessments of the Environment and Human health. To mitigate these toxic contaminants researchers devised different conventional and advanced methods such as chemical precipitation, chemical oxidation or reduction, ion exchange, sludge separation, reverse osmosis, membrane separation, electrochemical treatment, and evaporation. However, these methods face drawbacks as cost incompatibility, sludge production and removal inefficiency. Adsorption is a superior technique as compared to other methods of water treatment in terms of cost, the simplicity of design and operation, availability, effectiveness, and their insensitivity to toxic substances [8].

2. Experimental Section

2.1. Materials

2.1.1. Chemicals

Analytical reagent grade chemicals were used. Lead Nitrate (Pb $(NO_3)_2$), Potassium dichromate($K_2Cr_2O_7$), Nitric acid (HNO_3), Sodium hydroxide (NaOH), Sulphuric acid (H_2SO_4), Sodium carbonate ($NaCO_3$), Biphenyl carbazide and cadmium nitrate ($Cd(NO_3)_2$), Zinc Sulfate ($ZnSO_4$), Copper sulfate ($CuSO_4$), Phenol, (C_6H_5OH), 4-aminoantipyrine ($C_{11}H_{13}N_3O$), ferric cyanide ($[Fe(CN)_6]^{3-}$), chloroform ($CHCl_3$), & sodium sulphate ($NaSO_4$), distilled water.

2.1.2. Apparatus

Plastic bottles, Amber bottles, thermometer, volumetric flask, Measuring cylinder, Thermostatic water bath, Simple Distillation apparatus.

2.1.3. Instruments

Atomic Absorption spectrometry (AAS) (Model analytic jena nov AA 300, Germany), pH meter (HANNA instruments, pH 211), Conductometry, Electronic balance (Model AFP-110L, ADAM, China), Thermostatic water bath (Model Grant GLS 400, England), and UV-ViS Spectro photometry (Model DR 5000, Hach USA).

2.2. Methods

2.2.1. Collection of Water Sample

The study was conducted at Wollega University Chemistry laboratory, East Wollega.

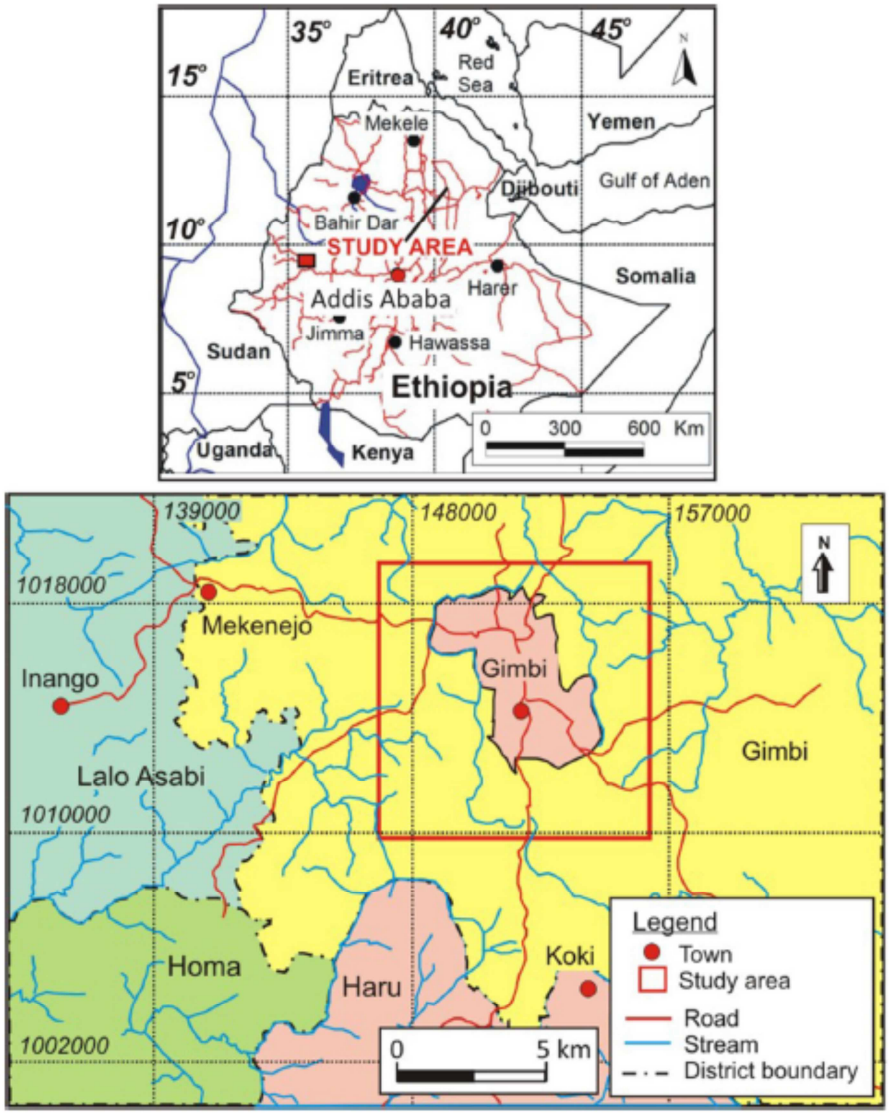

Figure 1. *Map of the Country; & sampling place Gimbi town in West Wollega.*

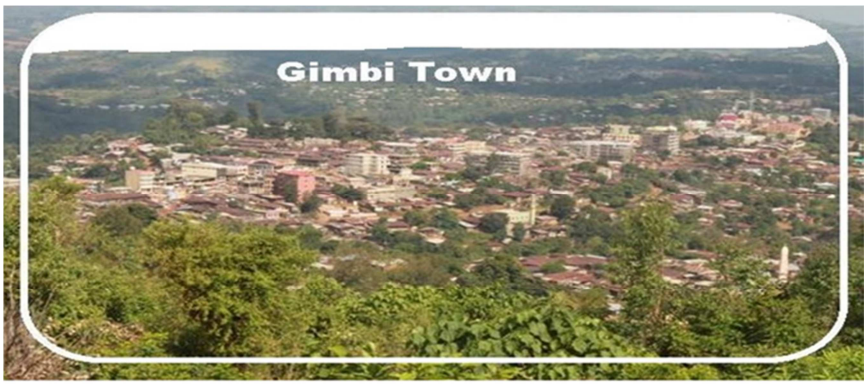

Figure 2. *Shows the overall view of the Gimbi town in West Wollega, and the sampling sites. Sample site: Sarxe, Medini, Malifu, Bus station, Isaksi (Colli).*

Sample containers were cleaned. Plastic bottles containers were washed with detergent and tap water followed by 1:1 HNO_3 and distilled water. Twenty Composite water sample in total 20x3=60 samples were collected in six (6^{th}) and seventh (7^{th}) month of 2011E. C. from different five sites of the town. Preservation of water samples were done by adding 2 drops of concentrated HNO_3 to each water sample before storage below 4 °C until analyzed. For Phenol analysis, Amber bottles were washed with detergent and water, rinsed with distilled water and air dried. Composite water samples were collected using Amber bottles and Preservation of water samples were done by adding 1 ml of 10 % NaOH prior to sampling.

2.2.2. Analysis of Pb (II), Zn (II), Cd (II), Cu (II) and Cr (VI) Concentration

The samples were digested using HNO_3. 100 mL of sample with 5 mL concentrated nitric acid were heated in a beaker on hot plate. Addition of acid was repeated till a light colored, clear solution is obtained. After cooling, the water samples were analyzed using AAS. Standard solutions and blanks were used in the process of analysis of all heavy metals & Phenol in analyzed water sample to ensure the precision. The concentration levels of Pb (II), Zn (II), Cd (II), Cu (II) and Cr (VI) in water were detected.

2.2.3. Analysis of Chromium (VI)

50 ml of a well-mixed solution was transferred to a 100 ml reagent bottle, and 5 mL solution of 2% NaOH and 3% Na_2CO_3 were added to it and heated at 95°C on a hotplate for 45 min. The solution was cooled and filtered and then transferred to a 25 mL volumetric flask. 2.0 mL sulfuric acid (6 N) was added to the solution in the volumetric flask and mixed. 0.5 ml Biphenyl carbazide solution was added, and the solution was diluted to the mark with distilled water and mixed. An aliquot of the solution in the flask was transferred to cuvette and analyzed using spectrophotometer at 540 nm. Stock solution (standard solution) and blanks were used for calibration curve and accuracy in the process of analysis.

2.2.4. Analysis of Phenol

Water samples were distilled using simple distillation and distillate was collected. The distillate was quantitatively transferred to a separately funnel; extracted using isobutyl acetate yield orange colour distillate. The absorbance of the extract was measured at a wavelength of 510 nm using UV-Visible spectrophotometer. Stock solution (Standard) and blank were analyzed by exactly the same procedure for calibration and accuracy.

3. Result and Discussion

3.1. Pb (II), Zn (II), Cu (II), Cd (II), Cr (VI) and Phenol Contents in Water

Study has been conducted and concentration level of Pb(II), Zn (II), Cu (II), Cd (II), Cr (VI) and total phenol were determined.

3.2. Calibration and Quality Control

Standard solution whose concentrations range from $\{0.000390625 - 0.00625\ mg/l\}$ were prepared from 100 mg/l stock solution of $K_2Cr_20_7$ and analyzed together with blanks. The result is shown by plotting absorbance vs concentration of standard solution.

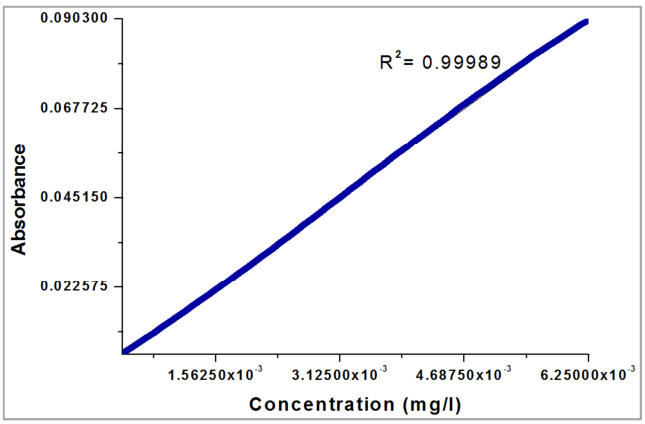

Figure 3. *A calibration graph of $K_2Cr_2O_7$ solution.*

In this study, composite water samples were collected from different five sites in Gimbi town. The samples collected were classified into Raw Water, Treated Water; (before and after distributed for residents), Ground and Surface Water).

The analysis were done as mean ±SD of three replicates.

Table 1. *The mean level of Heavy metals & Phenol contents in microgram per liter (µg/l) ±SD, in studied site.*

S. №	Sample site	Heavy metals						EC (µS/cm)	pH	T°	TDS (g/L)
		Pb (II)	Zn(II)	Cd(II)	Cu(II)	Cr(VI)	Total Phenol				
1	SW	0.35± 0.1	0.38±0.2	0.42±0.1	0.32±0.18	0.35±0.3	0.39±0.1	89	6.7	27.5°C	0.038
2	DSTW	0.34±0.19	0.34±0.2	0.41±0.2	0.54±0.3	0.37±0.25	0.3±0.23	84	7.0	25°C	0.00710
3	STW	0.49±0.19	0.35±0.3	0.31±0.1	0.64±0.4	0.35±0.25	0.62±0.13	83	7.1	25°C	0.00734
4	SSTWS1	0.51±0.19	0.33±0.31	0.421±0.1	0.35±0.4	0.39±0.27	0.31±0.24	83.15	7.3	25°C	0.00725
5	SSTWS2	0.41±0.18	0.31±0.1	0.31±0.1	0.55±0.3	0.36±0.25	0.39±.15	88.25	7.3	25°C	0.0232
6	SSTWS3	0.59±0.18	0.34±0.1	0.31±0.1	0.63±0.3	0.31±0.25	0.63±0.3	103.6	7.1	25°C	0.00497
7	RW	0.788±0.238	0.42±0.2	0.32±0.1	0.72±0.21	0.3± 0.23	0.4±0.2	89.8	6.9	25°C	0.0776
8	RW+Al	0.68±0.20	0.36±0.16	0.41±0.1	0.84±0.11	0.3±0.2	0.31±0.23	94.4	6.8	25°C	0.00610
9	RW+Cl	0.47±0.11	0.37±0.3	0.41±0.1	0.97±0.11	0.34±0.13	0.41±0.25	96.3	6.8	25°C	0.00506
10	DWIS1	0.49±0.18	0.45±0.1	0.3±0.1	0.83±0.18	0.32±0.29	0.87±0.1	91	6.5	25°C	0.0537

S. №	Sample site	Heavy metals						EC (µS/cm)	pH	T^{O}	TDS (g/L)
		Pb (II)	Zn(II)	Cd(II)	Cu(II)	Cr(VI)	Total Phenol				
11	DWIS2	0.56±0.23	0.55±0.2	0.42±0.32	0.5±0.13	0.315±0.7	0.42±0.13	95.9	6.7	25℃	0.0254
12	DWBST	0.51±0.1	0.92±0.40	0.52±0.1	0.38±0.27	0.48±0.4	0.74±0.3	96	6.4	25℃	0.0238
13	DWMA1	0.53±0.1	0.41±0.2	0.53±0.1	0.90±0.18	0.5±0.27	0.85±0.3	93	6.46	24℃	0.04453
14	DWMA2	0.42±0.7	0.38±0.1	0.42±0.1	0.60±0.5	0.40±0.1	0.94±0.4	93.5	6.26	23.5℃	0.03347
15	DWM1	0.44 ±0.18	0.45±0.1	0.41±0.3	0.48±0.18	0.52±0.28	0.93±0.5	91	6.5	24℃	0.0102
16	DWM2	0.45±0.32	0.44±0.29	0.52±0.1	0.53±0.16	0.34±0.1	0.99±0.1	92	6.5	24℃	0.0640
17	DWME1	0.42 ±0.36	0.77±0.36	0.62±0.3	0.52±0.19	0.32±0.12	0.87±0.4	88	6.6	23.5℃	0.0489
18	DWME2	0.45±0.32	0.76±0.19	0.42±0.2	0.41±0.21	0.35±0.20	0.92±0.2	86	6.3	24℃	0.00645
19	DWS1	0.71±0.18	0.54±0.6	0.41±0.2	0.72±0.18	0.36±0.23	0.94±0.6	91	6.3	25℃	0.00382
20	DWS2	0.59±0.15	0.31±0.13	0.65±0.3	0.65±0.1	0.32±0.2	0.93±0.3	93	6.7	25℃	0.00381
MPL (µg/l)		10	50	3	2000	50	200				

Where MPL (µg/l) represents Maximum permissible limit in drinking water
SW: Surface water, DW: Drinking water
STW: Stream water

Table 1: Shows that Surface water, Raw water, Treated water, and Stream water in Gimbi town had Heavy metals and Phenol contents within acceptable level as WHO guide line. Concentration of Heavy metal ions and Phenol in the samples analyzed are found in the Range: Lead (II) (0.34 µg/l - 0.78 µg/l), Cadmium (II) (0.3 µg/l - 0.62 µg/l), Chromium (VI) (0.3 µg/l - 0.52 µg/l), Copper (II) (0.32 µg/l - 0.97 µg/l), Zinc (II) (0.31 µg/l - 0.92 µg/l) and Phenol (0.3 µg/l – 0.99 µg/l). The concentration, C (µg/l), of Cr (VI) in the water sample were calculated using standard calibration curve. As shown from the Table 1: Heavy metal and Phenol concentration in Surface, Treated and Ground water are found within acceptable limit. This could be probably as a result of less agricultural runoff, city street runoff with season, construction sites, residential lawns and accumulation of pollutants which can easily reach the water source by erosion. In this study, Heavy metal and Phenol concentrations were determined and the results showed there is different between Heavy metal and Phenol concentrations in different geographical location of the town. Variation in the concentrations of Heavy metals and Phenol are probably the results of water distribution pipe lines and the presence of automobile, garages, and gasoline in the area which can be considered as sources of pollution. Lead is the most significant of all the Heavy metals because it is toxic at concentration above allowed level, and very common and harmful even in small amounts. Lead enters the human body in many ways. It can be inhaled in dust from Lead paints, or waste gases from Leaded gasoline. It is found in trace amounts in various foods, notably in fish, which are heavily subjected to Industrial pollution. Some homes may have Lead containing water pipes, which could be source of contaminants for drinking water. High concentration of Lead in the body can cause damage to the central nervous system, the brain, and kidneys. In this study, Lead concentration (Table 1) was found within acceptable level Lead (II) (0.34 µg/l - 0.78 µg/l) in drinking water of samples analyzed.

Chromium is an essential micronutrient for animals and plants, and is considered as a biological and pollution significant element. Generally the natural content of Chromium in drinking water is very low except for the site with substantial Chromium deposits. Chromium in excess amounts toxic especially in the hexavalent form. Sub Chronic and Chronic exposure to Chromic acid can cause dermatitis and ulceration of the skin. Long-term exposure can cause kidney, liver, circulatory and nerve tissue damages.

Chromium often accumulates in aquatic life and is danger when eating Fish that may have been exposed to high level of Chromium [9,10]. In this study, Chromium (VI) was detected and its concentration is low (Table 1) in all of the sampling sites. Chromium (VI) (0.3 µg/l - 0.52 µg/l). Cr (VI) at the consumer's tap may arise from a variety of sources. Source waters may have naturally occurring or anthropogenically elevated levels of Cr (VI) [11]. Chromium may be added to water via leaching from distribution system materials typically used in water plant and distribution system infrastructure such as Cast Iron, Cement, and Stainless Steel, and this Chromium could be released to the water through leaching or corrosion of these materials [12, 13]. Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms [14]. Nevertheless, higher concentrations of Zinc can be toxic to the organism. It plays an important role in protein synthesis, and is a metal which shows fairly low concentration in surface water due to its restricted mobility from the place of rock weathering or from the natural sources [15, 16]. In this study, a minimum of Zinc concentration were recorded in all sites of water sampled. Zinc (II) (0.31 µg/l - 0.92 µg/l). Cadmium pollute water from corrosion of Zinc coated ("galvanized") pipes and fittings [17]. At higher concentrations, it is known to have a toxic potential [18]. The main sources of Cadmium are industrial activities; the metal is widely used in Electroplating, Pigments, Plastics, Stabilizers and Battery Industries [19]. Cadmium is highly toxic and responsible for several cases of poisoning through food [20]. Small quantities of Cadmium cause adverse changes in the arteries of human kidney [21]. It replaces Zinc biochemically and causes high blood pressures, kidney damage etc [22]. In the present study, Cadmium (II) concentration is determined and is within acceptable level in

all of the samples analyzed. Cadmium (II) (0.3 μg/l - 0.62 μg/l). Contamination of drinking water with high level of Copper may lead to Chronic Anemia [23]. In this study, concentration level of Copper is detected and is found at low concentration (Table 1) which is within acceptable limit in all the sampling areas most probably due to the low Copper related industrial and mining activities in the sampling sites [24]. Copper (II) (0.32 μg/l - 0.97 μg/l). Organic compounds can be considered as water pollutants if their concentration exceeds allowed level in drinking water. Phenol is essential as well as has disadvantages due to its toxicity nature. Phenol can be considered as water pollutant if becomes much that is greater than permissible limit. Water containing Phenol is characterized as bad odour and taste which causes Vomiting and nausea, increased respiratory rate, Anorexia, liver and kidney damage, and headache. In this study Phenol concentration is determined and is within acceptable limit. Phenol (0.3 μg/l – 0.99 μg/l).

4. Conclusion

Analysis of drinking water sample were carried out to develop a data base on the quality of water being consumed in different sites of Gimbi town. Parameters: Conductivity, Total Dissolved Solids (TDS), Temperature, pH, and Heavy metals; Cr (VI), Cd(II), Pb (II), Cu (II), Zn (II), and Phenol were analyzed. All samples contain Lead (II), Cadmium (II), Chromium (IV), Copper (II), Zinc (II) and Phenol, within acceptable limits recommended by WHO, 2008. Lead (II) (0.34 µg/l - 0.78 µg/l), Cadmium (II) (0.3 µg/l - 0.62 µg/l), Chromium (VI) (0.3 µg/l - 0.52 µg/l), Copper (II) (0.32 µg/l - 0.97 µg/l), Zinc (II) (0.31 µg/l - 0.92 µg/l) and Phenol (0.3 µg/l – 0.99 µg/l). Heavy metals and Phenol are toxic at concentration above allowed level and detrimental impacts become apparent when long term consumption of contaminated water occurs. It is therefore suggested that regular monitoring of Heavy metals and Phenol in drinking water and also food items should be performed in order to prevent excessive buildup of these Heavy metals and Phenol in the human food chain. Moreover, the study initiates the society to due attention for environmental quality in general.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] M. Soylak, 2017. Chemical Contaminants in drinking water: Erciyes Universities; Yayin, 104, 94-98.

[2] Hathi M. V., Patel A. D. & Parmar K. C., Acharya G. D., 2019. Chemical properties of groundwater in Bailoda Taluka region, north Gujarat, India.

[3] H. M. Hassan, Mustafa H. T.; 2019. Pb and Cr concentrations in the potable water of the eastern province of Saudi Arabia: Bull. Environ. Contam. Toxicol. 43, 529.

[4] Environmental Protection Agency, U. S. Method, 2018. Dissolved Hexavalent Chromium Determination in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography. 218.6. 45-54.

[5] International Organization for Standardization; 2016. Water quality determination of cobalt, nickel, copper, zinc, cadmium and lead. Geneva, 8288: 1986.

[6] Dionex Corporation, 2020. Determination of Cr (VI) in Water, Waste Water, and Solid Waste Extracts. 345-349.

[7] Ballinger G. D., 2018. Methods for Chemical analysis of water and wastes: EPA, Ohio, 78-87.

[8] Vennilamani S., Pattabhi K., Kadirvelu M. C., Karthika M.; Radhika N., 2017. Agricultural byproduct as metal adsorbent: Environmental Technology. 21 (10), 1091-10977.

[9] Stuewer D., & Broekaert J. A. C., Barnowski C., Jakubowski N., 2018. Speciation of chromium by direct coupling of ion exchange chromatography with ICP-MS. At. Spectrom, 1155 (12), 1155–1161. doi: 10.1039/a702120h.

[10] WHO Guidelines for drinking water quality, 2009. World Health Organization (WHO).

[11] Johansen V. C. & Hills L. M. 2017. Hexavalent Chromium in Cement Manufacturing: Literature Review, Portland cement Association, Skokie, IL;

[12] Toomuluri P. J. & Eckert Jr., J. O., Guo Q., 2018. Leachability of Regulated Metals from Cement-Mortar Linings. Journal AWWA, 90 (3), 62.

[13] Q. Guo, 2017. Increases of Lead and Chromium in Drinking Water from Using Cement-Mortar Lined Pipes: Initial Modeling and Assessment. Journal of Hazardous Materials, 56 (1-2), 181.

[14] A. H. Tuthill, 2021. Stainless Steel Piping. Journal AWWA, 86 (6), 67.

[15] Delidou K., Dermosonoglou D., Gregoriadou A., Tsoumparis P., Edipidi C & Katsougiann opoulos B., 2020. Heavy metals in drinking water in Thessaloniki area, Greece. Proceedings of the 7th International Conference on Environmental Science and technology, Aristotle University, Ermoupolis.

[16] A. Farag, Eweida A., 2020. Heavy metals in drinking water and their environmental impact on human health. International Conference on Environmental Hazards Mitigation, Cairo University, Egypt, pp. 542-556.

[17] Prasai T., Singh A. & Yami K. D., Jayana B. L., 2019. Assessment of drinking water quality of madhyapurthimi and study of antibiotic sensitivity against bacterial isolates. Nepal Journal of Science and Technology, 10: 167-172.

[18] Mosley M., Singh S.,2020. Trace metal levels in drinking water on Viti Levu, Fiji Islands S.pac.J.Nat.Sci.

[19] Shubhashish K., Pandey & R. Pandey J., 2018. Heavy metal contamination of Ganga river at Varanasi in relation to atmospheric deposition. Tropical Ecology, 51 (2): 365-373.

[20] Kaghazchi T., Soleimani M., Tajar A. F., 2019. Adsorption of Cadmium from aqueous solutions on Sulfurized Activated Carbon prepared from Nut Shells: Journal of Hazardous Materials. 165, 159-1164.

[21] Toskovic D. V., Pantelic G. K., Ristic N. M & Jovanic S. Rajkovic M. B., Lacnjevac C. M., Ralevic N. R., Stojanovic M. D., 2021. Identification of metals (Heavy and Radioactive) in drinking water by indirect analysis method based on scale tests. Sensors, 8: 2188-2207.

[22] Danamark.com., 2018.Heavy metals in drinking water, viewed August1, 2010, http://www.danamark.com/Heavymetals in drinking water/pdf.

[23] Tahawy M., Nassef M., Hannigan R., 2020. Determination of some Heavy metals in the environment of Sadat Industrial City. Proceeding of the 2nd Environmental Physics Conference, Cairo University, Egypt, pp. 145-152.

[24] Puttaiah E. T., Rajappa B., Manjappa S., 2021. Monitoring of Heavy metal concentration in Groundwater of Hakinaka Taluk, India. Contemporary Engineering Sciences, 3 (4): 183-190.