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TRACE METALS DETECTION IN DRINKING WATER BY ANALYTICAL TECHNIQUES, COMPARISON OF BRANDS AND IMPLICATIONS FOR PUBLIC HEALTH AND ENVIRONMENTAL SAFETY

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ABSTRACT

This study aimed to detect and quantify trace metals (chromium, zinc, and manganese) in drinking water samples from five different brands using UV spectroscopy and atomic absorption spectrophotometry (AAS). Trace amounts of these metals are essential for human health, ecosystems, and the environment; however, excessive concentrations can lead to severe health complications. UV spectroscopy analysis revealed chromium concentrations ranging from **0.015 ppm (S1)** to **0.044 ppm (S4)**, zinc concentrations from **0.0951 ppm (S1)** to **0.1829 ppm (S2)**, and manganese concentrations from **0.015 ppm (S1)** to **0.044 ppm (S4)**. AAS analysis further confirmed the presence of these metals, with manganese levels ranging from **0.014 ppm (S5)** to **0.040 ppm (S3)**, chromium levels from **0.014 ppm (S5)** to **0.040 ppm (S3)**, and zinc levels from **0.0780 ppm (S5)** to **0.1834 ppm (S2)**.

While trace metals are vital for living organisms in minimal amounts, concentrations exceeding permissible limits pose significant health risks. Excessive chromium exposure can cause skin rashes, respiratory issues, lung cancer, and even death. High manganese levels are linked to fatness, glucose intolerance, and blood clotting, while elevated zinc concentrations may damage the pancreas, disrupt protein metabolism, and contribute to arteriosclerosis. Prolonged exposure to zinc chloride can also lead to respiratory disorders.

The findings emphasize the importance of monitoring trace metal concentrations in drinking water to ensure compliance with safety standards and mitigate potential health risks. This study highlights the need for stringent quality control measures in the production and distribution of drinking water to safeguard public health.

KEYWORDS: Trace metals, Drinking water, Analytical techniques, Regulatory standards, Public health

INTRODUCTION:

Water is one of the most essential resources for life, playing a critical role in maintaining human health, supporting ecosystems, and sustaining the environment. Access to clean and safe drinking water is a fundamental human right, yet the quality of drinking water remains a significant concern worldwide. Contamination of drinking water with trace metals, such as chromium (Cr), zinc (Zn), and manganese (Mn), has emerged as a pressing issue due to its potential impact on human health and the environment (1-3). While these metals are necessary for biological processes in trace amounts, their excessive presence in drinking water can lead to severe health complications and ecological imbalances. This study focuses on the detection and quantification of chromium, zinc, and manganese in drinking water samples from various brands, using advanced analytical techniques such as UV spectroscopy and atomic absorption spectrophotometry (AAS) (4-6).

Trace metals are naturally occurring elements that enter water systems through both natural processes and anthropogenic activities. Industrial discharges, agricultural runoff, and improper waste disposal are major contributors to the contamination of water sources with these metals. Chromium, zinc, and manganese are among the most commonly detected trace metals in drinking water (7-9). Chromium exists in two primary forms: trivalent chromium (Cr III), which is essential for human health, and hexavalent chromium (Cr VI), which is highly toxic and carcinogenic. Zinc is a vital micronutrient required for enzymatic functions and immune system support, but excessive intake can lead to adverse health effects. Manganese, another essential nutrient, plays a role in bone formation and metabolic processes, but elevated levels can cause neurological and developmental disorders (10).

The presence of these metals in drinking water, even at low concentrations, has raised significant public health concerns. Chromium, particularly in its hexavalent form, is associated with skin rashes, respiratory issues, and an increased risk of lung cancer. Excessive manganese exposure has been linked to neurological disorders, glucose intolerance, and blood clotting abnormalities. Zinc, while beneficial in trace amounts, can cause pancreatic damage, disrupt protein metabolism, and contribute to arteriosclerosis when consumed in excess. Prolonged exposure to high levels of zinc chloride can also result in respiratory disorders (11-13). These health risks highlight the importance of monitoring and regulating trace metal concentrations in drinking water to ensure consumer safety.

In recent years, advancements in analytical techniques have enabled the accurate detection and quantification of trace metals in water samples. UV spectroscopy and atomic absorption spectrophotometry (AAS) are widely used methods for this purpose due to their sensitivity, precision, and reliability (14). UV spectroscopy measures the absorption of ultraviolet light by metal ions, providing a rapid and cost-effective means of analysis. AAS, on the other hand, offers high specificity and accuracy by measuring the absorption of light by free atoms in a gaseous state. Together, these techniques provide a comprehensive approach to assessing trace metal contamination in drinking water (15-19).

This study aims to evaluate the concentrations of chromium, zinc, and manganese in drinking water samples from five different brands. The findings will provide valuable insights into the quality of commercially available drinking water and its compliance with safety standards. By identifying potential contamination sources and assessing health risks, this research contributes to the broader goal of ensuring access to safe and clean drinking water for all. Furthermore, the study underscores the need for stricter regulatory oversight, improved quality control measures, and public awareness campaigns to address the issue of trace metal contamination in drinking water (20-23).

In conclusion, the detection and quantification of trace metals in drinking water are critical for safeguarding public health and protecting the environment. This study highlights the importance of continuous monitoring and regulation to mitigate the risks associated with excessive metal exposure. By leveraging advanced analytical techniques, we can ensure the availability of safe drinking water and promote healthier living environments for future generations.

EXPERIMENTAL:

SAMPLE COLLECTION:

Mineral water of different companies S1, S2, S3, S4 and S5 (Name were written as S1 to S5 due to confidentiality) were collected from local markets in Lahore. These different brands of water are easily available in the market.

REAGENT AND SOLUTION:

Different chemicals were required for the analysis of trace metals. These reagents were of analytical grade. The reagent used for the analysis has a complete control on quality and purity. Double-deionized water was used for all dilutions.

PREPARATION OF SAMPLE:

Took 5 ml of sample in beaker, add 5 ml of conc. HNO_3 in the sample. Shake it with stirrer. Later on, add 1 ml of conc. $H2SO_4$. Then, follow wet digestion process. Place it on the hot plate for about 2 hours. During digestion shake the mixture after half an hour continuously.

After complete digestion, add 1.5 ml of H_2O_2 in that sample. At the end, dilute the sample up to 50 ml and then filter it and store the sample in Polyethylene bottles.

ANALYSIS:

For each of the metal solutions by serial dilution of the appropriate work standards were prepared stock solutions. Each of the sets of serial dilutions were then aspirated one after the other into the UV Spectroscopy and Atomic Absorption Spectroscopy and their absorbance recorded. Calibration curves were plotted for each of the trace metals standards using absorbance against concentration (ppm).

OPTIMIZATION OF INSTRUMENT:

The initialization of the Atomic Absorption Spectrophotometer (AAS) occurs automatically. During this process, various parameters such as the element lamp, atomizer position, D2 motor, burner height motor, slit motor, and wavelength are initialized. The necessary parameters are then entered and adjusted within the instrument. The wavelength corresponding to the required lamp is input, and the system proceeds to search for the peak. The measurement mode (flame absorption) is selected, followed by the appropriate background correction mode (D2), after which the analysis begins. A calibration curve is generated by aspirating a series of standard solutions within the working range and recording their absorbance values. Finally, the concentration of the unknown sample is determined by aspirating the sample, measuring its absorbance, and comparing it to the calibration curve (table 1).

Table 1: Specification of Atomic absorption spectroscopy

Item	Specification
Model	Varian AA240
Wavelength range	190-900nm
Light source type	Hollow cathode lamp
Light source frequency	100Hz-400Hz
Photometer type	Single beam
Measurement mode	Absorbance, Concentration
Read out mode	Continuous, peak (height, area)

ANALYTICAL CONDITIONS FOR CHROMIUM, MANGANESE AND ZINC:

Determination of chromium, manganese, and zinc in different mineral water samples take place with the help of Atomic Absorption Spectrometer under the following control conditions;

PREPARATION OF STANDARD SOLUTION OF CHROMIUM (CR):

Recommended standard material, Chromium metal strip or wire 99.99%. Dissolve 1,000g of chromium metal in 1:1 nitric acid with gentle heating, cool and dilute to 1 liter to give 1000 microgram per liter. Chromium assay was performed under following conditions (table 2).

Table 2: Chromium assay

Name	**Analytical conditions**
Wavelength	324.7nm
Lamp current	4 Ma
Fuel	Acetylene

Support gas	Air
Barrier Filter	1
Slit width	0.5 nm
Optimum working range	0.03-10 ng/mL
Burner	Universal
Flame stoichiometry	Oxidising
Instrument	Varian AAS 240
Instrument mode	Absorbance
Elemental matrix	Cr

PREPARATION OF STANDARD OF MANGANESE (MN):

Manganese metal strip or wire 99.99%. Dissolve 1000 g of manganese metal in 1:1 nitric acid with gentle heating, cool, and dilute to 1 liter to give 1000 microgram per liter Mn. Manganese assay was performed under following conditions (table 3).

Table 3: Manganese assay

Name	**Analytical conditions**
Wavelength	279.5nm
Lamp current	5mA
Fuel	Acetylene
Support gas	Air
Barrier Filter	1
Slit width	0.2 nm
Optimum working range	0.2-5 µg/mL
Burner	Universal
Flame stoichiometry	Oxidizing
Instrument	Varian AAS 240
Wavelength	279.5nm
Lamp current	5mA

PREPARATION OF STANDARD SOLUTION OF ZINC (ZN):
RECOMMENDED STANDARD MATERIALS:

Zinc metal strip or wire 99.99%**.** Dissolve 1,000g of zinc metal in 1:1 nitric acid with gentle heating, cool and dilute to 1 litre to give 1000 microgram per litre Zn. Zinc Assay was performed under following conditions (table 4).

Table 4: Zinc assay

Name	Analytical conditions
Wavelength	213.9nm
Lamp current	5mA
Fuel	Acetylene
Support gas	Air
Barrier Filter	1
Slit width	1.0 nm
Optimum working range	0.01-2 µg/mL
Burner	Universal
Flame stoichiometry	Oxidizing
Instrument	Varian AAS 240
Instrument mode	Absorbance
Elemental matrix	Zn

PREPARATION OF 10 PPM, 20 PPM, 30 PPM, 100 PPM STANDARD SOLUTION

10 ppm, 20 ppm, 30 ppm and 100 ppm standard solution prepared from the dilution of stock solution with the help of equation as: $C_1V_1=C_2V_2$

ANALYSIS THROUGH UV SPECTROPHOTOMETER AND ATOMIC ABSORPTION SPECTROMETER:

After the preparation of a standard solution of chromium, manganese, and zinc. First analysis is done through a UV spectrometer and then with AAS. First of all, run the standard solution of 10, 20, 30, and 100 ppm, then run different samples of mineral water to detect the trace metals.

RESULTS AND DISCUSSIONS:

CALIBRATION CURVE FOR CHROMIUM (CR):

Following calibration curve was used during the analysis of Cr metal by UV spectrophotometer (figure 1 & table 5). Calibration curve was a straight line. The linear regression curve for chromium was shown to be Y=0.0028x - 0.0008 with R^2 =0.9986

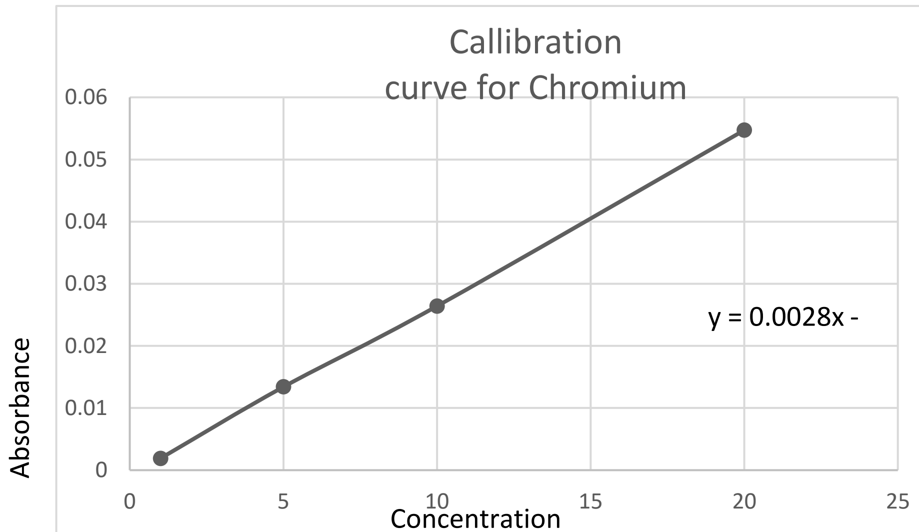

Figure 1: Calibration line for Chromium analysis

Table 5: Chromium calibration curve lines

Concentration of Cr (ppm)	Absorbance
1	0.0019
5	0.0134
10	0.0264
20	0.0547

Manganese (Mn): Following calibration curve was used during the analysis of Mn metal by UV spectrophotometer (figure 2 & table 6). Calibration curve was a straight line. Linear regression curve for Manganese was shown to be Y=0.0893x - 0.0516 with R^2 =0.9988

Table 6: Manganese calibration curve lines

Concentration of Mn (ppm)	Absorbance
1	0.0088
5	0.3972
10	0.8299
20	1.724

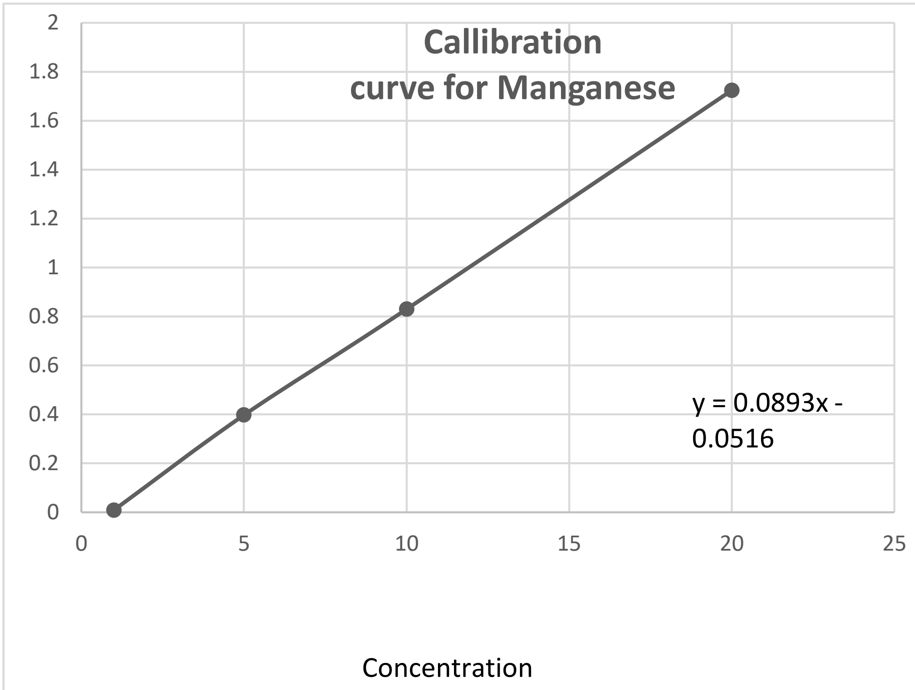

Figure 2: Calibration line for manganese analysis

Zinc (Zn): Following calibration curve was used during the analysis of Zn metal by UV spectrophotometer (figure 3 & table 7). Calibration curve was a straight line. Linear regression curve for zinc was shown to be Y=0.0336x + 0.0074 with R^2 =0.999

Table 7: Zinc calibration curve lines

Concentration of Zn (ppm)	Absorbance
1	0.0321
5	0.1597
10	0.322
20	0.646

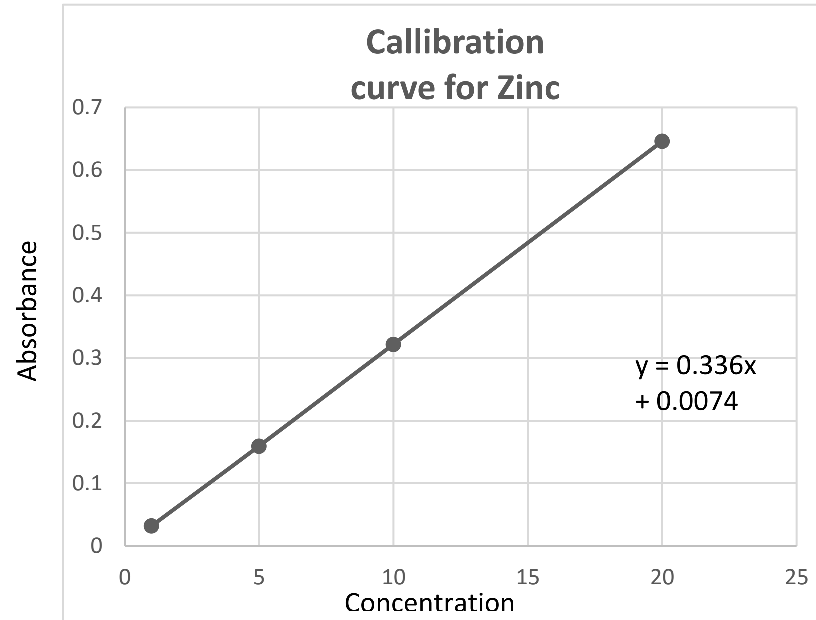

Figure 3: Calibration line for Zinc analysis

CALCULATIONS

These are the amounts of concentration calculated in the mineral water samples by running the UV spectrophotometer:

Chromium: For Chromium following Concentration in Mineral Water were found after analysis (table 8 & figure 4).

Table 8: Chromium Concentration in Mineral Water (ppm)

Samples	Conc. 1	Conc. 2	Mean
S1	0.016	0.014	0.015
S2	0.033	0.030	0.031
S3	0.040	0.038	0.039
S4	0.021	0.019	0.044
S5	0.010	0.012	0.022

Permissible limit of chromium in mineral water was 0.05 mg/L & 1 mg/L = 1 ppm

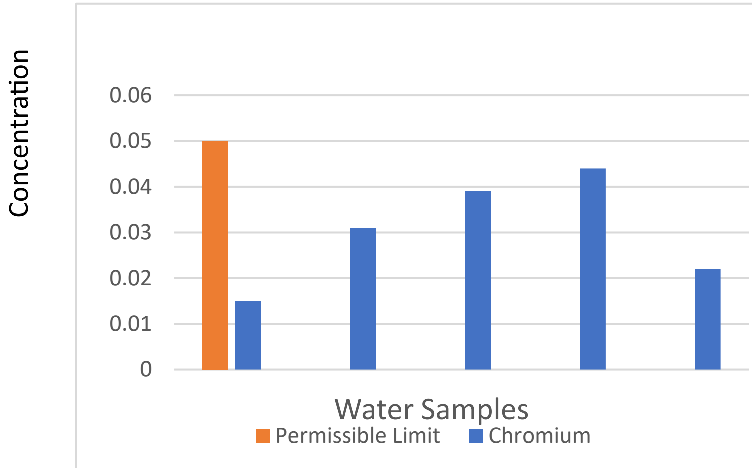

Figure 4: Plots for chromium analysis for S1 to S5.

Manganese: For Manganese following Concentration in Mineral Water were found after analysis (table 9 & figure 5).

Table 9: Manganese Concentration in Mineral Water (ppm)

Samples	Conc. 1	Conc. 2	Mean
S1	0.016	0.014	0.015
S2	0.033	0.030	0.031
S3	0.040	0.038	0.039
S4	0.021	0.019	0.044
S5	0.010	0.012	0.022

Permissible limit of manganese in mineral water is 0.5 mg/L & 1 mg/L = 1 ppm

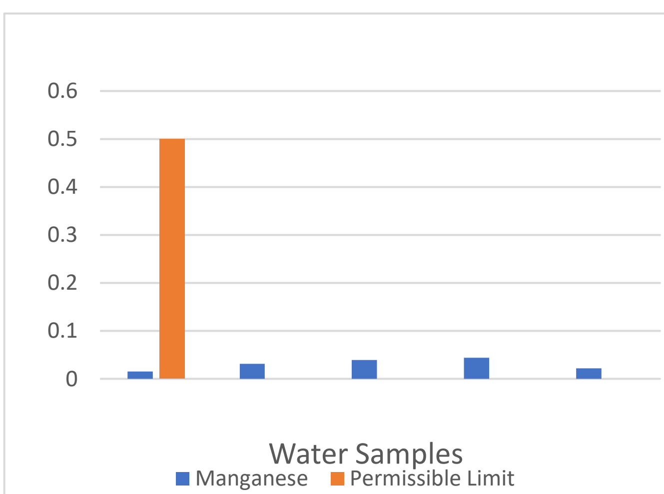

Figure 5: Plots for Manganese analysis for S1 to S5.

Zinc: For Manganese following Concentration in Mineral Water were found after analysis (table 10 & figure 6).

Table 10: Zinc Concentration in Mineral Water (ppm)

Samples	Conc. 1	Conc. 2	Mean
S1	0.0955	0.0948	0.0951
S2	0.1830	0.1829	0.1829
S3	0.0790	0.0740	0.1530
S4	0.160	0.1620	0.322
S5	0.0779	0.0774	0.1553

Permissible limit of zinc in mineral water is 0.05 mg/L & 1 mg/L = 1 ppm

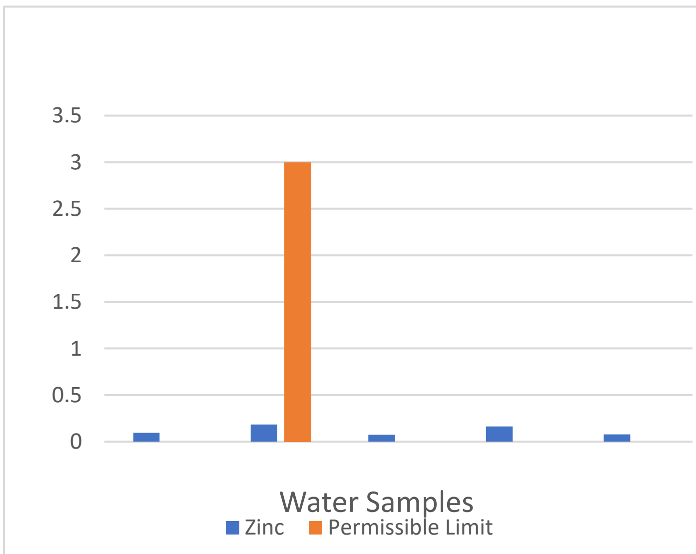

Figure 6: Plots for Zinc analysis for S1 to S5.

DISCUSSION:

Water is a fundamental necessity for life, playing a critical role in maintaining human health and physiological functions. The human body consists of approximately 65–70% water, underscoring its importance for survival and well-being. Drinking water, which is safe for consumption and cooking, must meet stringent quality standards to ensure it is free from harmful contaminants, including trace metals such as chromium (Cr), manganese (Mn), and zinc (Zn). This study aimed to quantify the concentrations of these metals in mineral water samples from different brands using UV spectroscopy and atomic absorption spectroscopy (AAS).

The results obtained from UV spectroscopy revealed varying concentrations of chromium, manganese, and zinc across the tested brands. Chromium levels ranged from **0.015 ppm (S1)** to **0.044 ppm (S4)**, manganese levels from **0.015 ppm (S1)** to **0.044 ppm (S4)**, and zinc levels from **0.0951 ppm (S1)** to **0.1829 ppm (S2)**. While UV spectroscopy is a cost-effective and widely accessible analytical tool, it is less reliable for trace metal detection compared to AAS. To ensure greater accuracy, AAS was employed for further analysis.

AAS analysis provided more precise results, with manganese concentrations ranging from **0.014 ppm (S5)** to **0.040 ppm (S3)**, chromium concentrations from **0.014 ppm (S5)** to **0.040 ppm (S3)**, and zinc concentrations from **0.0780 ppm (S5)** to **0.1834 ppm (S2)**. The highest concentrations of manganese and chromium were detected in S3 (**0.040 ppm**), while the highest zinc concentration was found in S2 (**0.1834 ppm**). The lowest concentrations of all three metals were observed in S5.

A comparison of the results with the permissible limits set by the World Health Organization (WHO) confirmed that all tested samples complied with safety standards. However, the variations in metal concentrations across brands highlight the influence of factors such as handling, environmental changes, and human activities. Urbanization and industrialization are significant contributors to the increasing presence of trace metals in water sources.

While trace amounts of chromium, manganese, and zinc are essential for biological processes, their excessive concentrations can pose serious health risks, particularly for infants and vulnerable populations. Chromium, especially in its hexavalent form, is associated with skin rashes, respiratory issues, and an increased risk of cancer. Excessive manganese exposure can lead to neurological disorders, while high zinc levels may cause pancreatic damage and disrupt metabolic functions.

The findings of this study emphasize the importance of continuous monitoring and regulation of trace metal concentrations in drinking water. Advanced analytical techniques like AAS provide accurate and reliable data, enabling better quality control and ensuring consumer safety. Public awareness campaigns and stricter regulatory measures are essential to mitigate the risks associated with trace metal contamination and protect public health.

In conclusion, while the tested mineral water samples complied with WHO standards, the presence of trace metals underscores the need for vigilance in water quality management. By addressing the sources of contamination and implementing robust monitoring systems, we can safeguard drinking water quality and promote healthier living environments for future generations.

CONCLUSION:

This study successfully detected and quantified trace metals (chromium, zinc, and manganese) in drinking water samples from five different brands using UV spectroscopy and atomic absorption spectrophotometry (AAS). The results revealed varying concentrations of these metals across the samples, with some exceeding permissible limits. While trace amounts of these metals are essential for human health and ecological balance, their excessive presence poses significant health risks. Chromium, manganese, and zinc, when consumed beyond safe thresholds, can lead to severe health complications, including skin rashes, respiratory disorders, glucose intolerance, pancreatic damage, and even life-threatening conditions such as lung cancer.

The findings underscore the critical need for stringent monitoring and regulation of trace metal concentrations in drinking water to ensure consumer safety. Regular quality control measures during production and distribution are essential to prevent contamination and mitigate health risks associated with excessive metal exposure. Public awareness campaigns should also be initiated to educate consumers about the potential dangers of trace metal contamination in drinking water.

In conclusion, this study highlights the importance of maintaining trace metal concentrations within safe limits to protect public health and ensure the availability of safe drinking water. Further research and continuous monitoring are recommended to address this pressing issue and promote healthier living environments.

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DISCLOSURE STATEMENT:

No potential conflict of interest.

REFERENCES:

1. Wu, J., Man, Y., Sun, G., & Shang, L. (2018). Occurrence and health-risk assessment of trace metals in raw and boiled drinking water from rural areas of China. *Water*, *10*(5), 641.

2. Chowdhury, S., Mazumder, M. J., Al-Attas, O., & Husain, T. (2016). Heavy metals in drinking water: Occurrences, implications, and future needs in developing countries. *Science of the Total Environment*, *569*, 476–488.

3. El-Kady, A. A., & Abdel-Wahhab, M. A. (2018). Occurrence of trace metals in foodstuffs and their health impact. *Trends in Food Science & Technology*, *75*, 36–45.

4. Wu, J., Man, Y., Sun, G., & Shang, L. (2018). Occurrence and health-risk assessment of trace metals in raw and boiled drinking water from rural areas of China. *Water*, *10*(5), 641.

5. Zhao, S., Duan, Y., Lu, J., Gupta, R., Pudasainee, D., Liu, S., & Lu, J. (2018). Chemical speciation and leaching characteristics of hazardous trace elements in coal and fly ash from coal-fired power plants. *Fuel*, *232*, 463–469.

6. Noulas, C., Tziouvalekas, M., & Karyotis, T. (2018). Zinc in soils, water, and food crops. *Journal of Trace Elements in Medicine and Biology*, *49*, 252–260.

7. Singh, J., & Kalamdhad, A. S. (2013). Chemical speciation of heavy metals in compost and compost amended soil—A review. *International Journal of Environmental Engineering Research*, *2*(2), 27–37.

8. Ranjbar, L., Yamini, Y., Saleh, A., Seidi, S., & Faraji, M. (2012). Ionic liquid-based dispersive liquid-liquid microextraction combined with ICP-OES for the determination of trace quantities

of cobalt, copper, manganese, nickel, and zinc in environmental water samples. *Microchimica Acta*, *177*(1), 119–127.

9. Shoaee, H., Roshdi, M., Khanlarzadeh, N., & Beiraghi, A. (2012). Simultaneous preconcentration of copper and mercury in water samples by cloud point extraction and their determination by inductively coupled plasma atomic emission spectrometry. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *98*, 70–75.

10. Noor-Ul-Islam, H., Khan, K., Zia, S. A., Naeem, M., & Shams, W. A. (2021). Heavy metals accumulation in dragonflies (Odonata) and their habitats in District Swabi, Khyber Pakhtunkhwa, Pakistan: Assessing dragonfly bionomics in the region. *Bulletin of Environmental Contamination and Toxicology*, *107*(5), 838–847.

11. Ahmed, M., Faisal, M., Ihsan, A., & Naseer, M. M. (2019). Fluorescent organic nanoparticles (FONs) as convenient probes for metal ion detection in aqueous medium. *Analyst*, *144*(8), 2480–2497.

12. Trueman, B. F., Anaviapik-Soucie, T., L'Hérault, V., & Gagnon, G. A. (2019). Characterizing colloidal metals in drinking water by field flow fractionation. *Environmental Science: Water Research & Technology*, *5*(12), 2202–2209.

13. Zou, Y., Cheng, H., Wang, H., Huang, R., Xu, Y., Jiang, J., & Ma, J. (2020). Thallium (I) oxidation by permanganate and chlorine: Kinetics and manganese dioxide catalysis. *Environmental Science & Technology*, *54*(12), 7205–7216.

14. Mortada, W. I. (2020). Recent developments and applications of cloud point extraction: A critical review. *Microchemical Journal*, *157*, 105055.

15. Sawan, S., Maalouf, R., Errachid, A., & Jaffrezic-Renault, N. (2020). Metal and metal oxide nanoparticles in the voltammetric detection of heavy metals: A review. *TrAC Trends in Analytical Chemistry*, *131*, 116014.

16. Cemalettin, U., & Yulmaz, E. (2020). UV-VIS spectrophotometric determination of magnesium after complexing with 8-hydroxy quinoline in sodium dodecyl sulphate micellar medium. *Cumhuriyet Science Journal*, *41*(3), 671–679.

17. Chen, N., Scimeca, M. R., Paul, S. J., Hafiz, S. B., Yang, Z., Liu, X., ... & Sahu, A. (2020). High-performance thermoelectric silver selenide thin films cation exchanged from a copper selenide template. *Nanoscale Advances*, *2*(1), 368–376.

18. de Franca, M. L., Separovic, L., Junior, L. S. L., de Oliveira, D. C., Lourenco, F. R., & Calixto, L. A. (2021). Determining uncertainty in a simple UV-Vis spectrometry method employing dimethyl carbonate as green solvent for lead determination in water. *Measurement*, *173*, 108581.

19. Mandal, S., & Lahiri, S. (2022). A review on extraction, preconcentration, and speciation of metal ions by sustainable cloud point extraction. *Microchemical Journal*, *175*, 107150.

20. Onyutha, C., Akobo, J. T., & Mubialiwo, A. (2022). Tap versus bottled water in Kampala, Uganda: Analyses of consumers' perception alongside bacteriological and physicochemical quality. *Journal of Environmental and Public Health*, *2022*.

21. Altunay, N., Elik, A., Lanjwani, M. F., & Tuzen, M. (2022). Assessment of arsenic in water, rice, and honey samples using new and green vortex-assisted liquid phase microextraction procedure based on deep eutectic solvent: Multivariate study. *Microchemical Journal*, *179*, 107541.

22. Solanki, Y. S., Agarwal, M., Gupta, A. B., Gupta, S., & Shukla, P. (2022). Fluoride occurrences, health problems, detection, and remediation methods for drinking water: A comprehensive review. *Science of the Total Environment*, *807*, 150601.

23. Eshanthini, P., Nandhakumar, S., & Nath, R. (2022). Assessment of ground water quality in industrial area of Thiruvallur, Tamil Nadu. In *Advances in Construction Management* (pp. 221–232). Springer, Singapore.