GUB Journal of Science and Engineering (GUBJSE)
p-ISSN: 2409-0476
vol. 09, no. 01, 2022

Iodine and goitrogens distribution in drinking water of some secondary schools of Kebbi, Nigeria

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Received: 10/07/2022
Accepted: 27/09/2022
Published: 13/07/2024

Data Availability: The data are available on request from the corresponding author.

Competing Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DOI: 10.3329/gubjse.v9i1.74881

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Abstract

The objective of this paper is to carry out an evaluation of iodine, calcium, magnesium, and other goitrogenic factors in drinking water obtained from three schools in Kebbi Local Government Area, Kebbi State, Nigeria. Standard methods and procedures including atomic absorption spectroscopy were utilized to attain the objective of the study. One-way analysis of variance (ANOVA) test was carried out and results are significant at ($p < 0.05$). The amounts of iodine, magnesium, phosphate, and calcium were in the ranges of 0.250 ± 0.02 - 0.120 ± 0.03 ppm, 2.2 ± 0.01- 10.0 ± 0.01 ppm, 0.03 ± 0.0001 -0.07 ± 0.0001 ppm, 3.4 ± 0.01 - 8.5 ± 0.01 ppm. There were diverse levels of the studied goitrogens. Fluoride, bromide, chloride, cyanide, perchlorate, and nitrate are in respective ranges as follows: 1.12 ± 0.02 - 3.14 ± 0.02 ppm, 0.02 ± 0.002 - 0.15 ± 0.002 ppm, 0.61 ± 0.002 - 1.21 ± 0.02 ppm, 0.32 ± 0.001 - 0.51 ± 0.001 ppm, 0.120 ± 0.0001- 0.250 ± 0.02 ppm, and 2.2 ± 0.02 – 10.0 ± 0.01 ppm respectively. The result has revealed that the water used in the studied schools contains goitrogens that can contribute to the interference in iodine metabolism and leading to consequent harmful effects on youngsters.

Keywords: Iodine, nitrate, chloride, goiter, goitrogens, water, pollution

Highlights

- Evaluation of essential elements and goitrogenic factors in school drinking water.
- Significant presence of iodine, magnesium, and goitrogens in water samples.
- Potential health implications on youngsters due to goitrogenic factors in water.
- Importance of regular assessment of water quality in semi-desert regions like Kebbi State.

Acknowledgements

This paper and the research behind it would not have been possible without the laboratory supports of the Central Advanced Laboratory of Usmanu Danfodiyo University Sokoto, Nigeria.

1 Introduction

WASH (water, sanitation, and hygiene) is important in schools. The hygiene facilities aid in providing positive outcomes on the students, students of need privacy, aid in creative development of students, facilitates psychological development, and safeguard physical health of students [1]. More than 800 school-aged children are dying everyday due to water related problems, every year about 85, 700 children die due to water related issues that could have been avoided with safe water availability [2], [3]. Schools are expected to ensure the presence of WASH to provide healthy and safe environment for students to live and learn effectively [3]. Water remains the most important nutrient in the life of biological systems including human beings necessary for the perpetuation of entire processes taking place in the human body. Good quality water is necessary for health especially in carrying out body processes like enzyme activities, digestion, transport of materials within the body, absorption, temperature modulation, excretion, and lubrication of diverse body parts [4]–[6]. Water is indeed a great fluid of living thing and act as a universal solvent [7].

However, nowadays, there is increased concern about the quality of drinking water due to rampant pollution that set water as tool that convey harmful contents including microbes and chemicals to food chain and ultimately debilitates the humans in many ways [7]–[10]. Thus, it is an act of management, more importantly in areas that are semi-desert like Kebbi State to regularly assess the quality of water by measuring some parameters such as goitrogenic factors; because, in areas of such kind low quality drinking water is prevalent, and poor water policies are evident [10]. This has led to incorporation of harmful chemicals into the drinking water. These harmful chemicals that are found in water due to contamination includes the goitrogenic factors such as chloride, cyanide, fluoride, phosphate, and the likes [11], [12]. There is unequivocal relationship between the environmental pollution, health of humans, food/ water intake and diseases [9], [12]–[15].

More specifically, the concentrations of iodine (an essential microelement of humans) being taken in food, water, and relations are related to the health of thyroid gland. Therefore, when there exists little or too much iodine in water, coupled with goitrogens adverse conditions are bound to happened characterized with many harmful effects [12], [13]. Optimum iodine level and proper iodine metabolism are important aspects tied up with normal thyroid gland that in turns releases thyroxine that promotes growth and development of muscle, bone, height, weight; and the hormone is needed for stabilization of material and energy metabolic activities [12], [13]. In tandem with the role of iodine to the body, excess or insufficient iodine cause hyperthyroidism, hypothyroidism, mental retardation, goiter, thyroid carcinoma, autoimmune disorder, and relations especially in children and youngsters [12]–[14], [16].

Goitrogens act as opposite of iodine in the body by impairing the uptake of the element or affecting ways of iodine metabolism [17]. Among the major sources of goitrogens, is the water polluted by nitrate, cyanide, and specific ions (including fluoride, calcium, bromide, and magnesium). Areas challenged with goiter have been reported to have water that contains enough goitrogens that instigate low iodine content [17]. Long-term exposure to goitrogens can impact on thyroid functions by causing low iodine intake . Indeed goitrogens directly or through proxy changes the thyroid gland, peripheral metabolism, release of T3 (triiodothyronine) /T4(thyroxin). The thyroid gland is highly sensitive, and respond to iodine metabolism with difficulties in brain development, basal metabolism, enlargement. Specifically, perchlorate cause a decrease in thyroid hormone reserve (hypothyroidism) [18]; cyanide binds iodine in the body to affect its concentration; Ca and Mg ions of excess levels induce goiter or iodine deficiency in water or human body through prevention of iodine utilization [19] Principally, iodine deficiency occurs due to low intake of iodine from food materials including water. Unfortunately, iodine deficiency is a main public health thing, especially among children, and pregnant women. The deficiency is of great concern due to being a cause of mental retardation, and cognitive impairment [13].

Meanwhile, women or girls taking low iodine are at great risk of breast cancer, miscarriage, congenital problems, perinatal death [16]. Children or younger ones with iodine deficiency are at the risk of growth failure, mental retardation, goiter, diminished productivity, and deafness [17]. Iodine is on many occasions insoluble in water unless modification enhanced it's solubility [20]. Water iodine, and goitrogenic levels are indicators that could portend iodine levels in soils for plants uptake and upward shuttling in the food chain. Likewise, in Kebbi area, like other places where there are, soil erosion (or any other form of soil degradation), excessive cattle grazing, deforestation for housing or fuel or other means, hot temperature (that cause volatilization); there is risk of loss of iodine from environmental sources and in turns affects human intake. Therefore, it is pertinent to measure iodine in water consumed at schools to help in providing data that could be used in safeguarding health and solving poor performance issues among young ones [16].

Therefore, the objective of this work is to execute an evaluation of iodine, calcium, magnesium, and other goitrogenic factors in drinking water obtained from three schools in

Kebbi Local Government Area, Kebbi State, Nigeria.

2 Methodology

2.1 Study area

The study was carried out in in Birnin Kebbi Local Government of Kebbi State, Nigeria. Accordingly, the population of Birnin Kebbi Local Government is estimated to be about 268, 420.

2.2 Goitrogenic Factors Evaluation

Iodine and other goitrogenic factors were determined after collecting drinking water samples from three secondary schools in Birnin Kebbi Local Government Area, Nigeria. Triplicate analysis was done for each sample and mean, and standard deviation were deducted. The method employed for the evaluation of element was according to methods outlined in Umar et al [17]. Results of analysis were reported as mean ± standard deviation in ppm units (P ¡ 0.05). Difference between the mean obtained from the ANOVA were ascertained using Duncan's post hoc multiple range test.

3 Results and Discussion

Evaluation of iodine, calcium, magnesium, and other goitrogenic factors in drinking water obtained from three schools in Birnin Kebbi Local Government Area, Nigeria, was the main objective of this paper. Therefore, the results for this study were delivered by Tables 1 - 6.

Table 1. Evaluated iodine, calcium, phosphate, and magnesium contents in water from certain schools in Kebbi, Nigeria

Name of school	IODINE (ppm)	MAGNESIUM (ppm)	PHOSPHATE(ppm)	CALCIUM (ppm)
School A	0.120 ± 0.03	10.0 ± 0.01	0.03 ± 0.0001	8.5 ± 0.01
School B	0.123 ± 0.01	4.8 ± 0.03	0.06 ± 0.0002	4.5 ± 0.03
School C	0.250 ± 0.02	2.2 ± 0.01	0.07 ± 0.0001	3.4 ± 0.01

The Anova results show that, f-statistic value=5.18905, and p-value=0.02787. The Table 1 delivered the result of iodine, magnesium, phosphate and calcium found in well water of some secondary schools in Birnin Kebbi Local Government Area, Nigeria. The levels of iodine, magnesium, phosphate, and calcium were in the ranges of 0.250 ± 0.02 - 0.120 ± 0.03 ppm, 2.2 ± 0.01 - 10.0 ± 0.01 ppm, 0.03 ± 0.0001 - 0.07 ± 0.0001 ppm, 3.4 ± 0.01 - 8.5 ± 0.01 ppm. The elements shown by Table 1 are indeed essential to the body in many biological activities, but sometimes when their levels are high act to cause negative effects such as the incitement of goiter or thyroid gland problems especially in regions that experience endemic goiter or endemic iodine deficiency disorders. The concentrations of calcium, magnesium, and phosphate found by this study in drinking water of secondary schools are in congruent to what was obtained in water in another Sokoto study on poultry water [4], albeit lower than the levels found in a study of water bodies in Ondo, Nigeria by Salawu et al. [17]. These calcium, magnesium parameters discovered in this study should be queried as they are related to hardness that reduces the efficiency of the water in many respects, especially the ability of calcium and magnesium to cause hardness of the water and make iodine non-available for uptake by consumers [4]. The iodine obtained by this study is very much higher than the one found in waterbodies in the study related by Salawu et al. [17].

Table 2. Evaluated fluoride, bromide, and other goitrogenic factors present in drinking water obtained from certain schools in Kebbi, Nigeria

Name of school	FLOURIDE (ppm)	BROMIDE (ppm)	CHLORIDE (ppm)	CYANIDE (ppm)
School A	1.12 ± 0.02	0.02 ± 0.002	1.21 ± 0.02	0.41 ± 0.02
School B	2.22 ± 0.01	0.08 ± 0.002	0.61 ± 0.002	0.51 ± 0.001
School C	3.14 ± 0.02	0.15 ± 0.002	0.91 ± 0.002	0.32 ± 0.001

Table 3. Evaluated perchlorate, and nitrate contents in water from certain schools in Kebbi, Nigeria

Name of school	PERCHLORATE (ppm)	NITRATE (ppm)
School A	0.120 ± 0.03	10.0 ± 0.01
School B	0.123 ± 0.01	4.8 ± 0.03
School C	0.250 ± 0.02	2.2 ± 0.01

The Anova results show that, f-statistic value= 6.88644, and p-value= 0.003. Table 2 shows the different concentrations of fluoride, bromide, chloride, cyanide, perchlorate, and nitrate obtained in well drinking water of some secondary schools in Birnin Kebbi Local Government Area, Nigeria. There were diverse levels of the studied goitrogens. fluoride, bromide, chloride, cyanide, perchlorate,

Table 4. Evaluated iodine/goitrogenic factors of water from some secondary schools in Kebbi, Nigeria

Name of school	FLOURIDE	BROMIDE	CHLORIDE	CYANIDE
School A	0.107142	6.0000	0.09917	0.292682
School B	0.055405	1.5375	0.20163	0.241176
School C	0.079617	16.6666	0.27472	0.78125

Table 5. Evaluated iodine/Goitrogenic factors pertaining perchlorate, and nitrate of water from certain schools in Kebbi, Nigeria

Name of school	PERCHLORATE	NITRATE
School A	1	0.12
School B	1	0.0256
School C	1	0.1136

and nitrate are in respective ranges as follows: 1.12 ± 0.02 - 3.14 ± 0.02 ppm, 0.02 ± 0.002 - 0.15 ± 0.002 ppm, 0.61 ± 0.002 - 1.21 ± 0.02ppm, 0.32 ± 0.001 - 0.51 ± 0.001 ppm, 0.120 ± 0.0001- 0.250 ± 0.02 ppm, and 2.2 ± 0.02 – 10.0 ± 0.01 ppm respectively. However, the levels of bromide, and chloride in this study are similar to concentrations obtained from vegetable plants of southwestern Nigeria [18]. Bromide or chloride exerts effect on the thyroid gland by reducing the amount of iodide accumulating in the thyroid gland and in turn reduces the iodine to the body. Other effect of chloride or bromide is the increase in the excretion of iodine in urine. The fluoride revealed by this study is higher than the levels obtained from water collected from water bodies in Ondo as indicated elsewhere [17]. Nitrate is an endocrine as well as thyroid disturber of its own, that for instance form N-nitro components [21]. Albeit, nitrate in observed by this study is lower than the WHO nitrate guideline for drinking water [21], nitrate obtained few years ago in poultry water in Sokoto was higher than the concentration found by this study, a difference that might be due to geological differences and difference in extent of water pollution between the two samples [4]. Likewise, presence of much fluoride in water is an indication of pollution. Nitrate, perchlorate, and cyanide are examples of goitrogens (substances that interfere with thyroid gland or iodine metabolism) that were found by this study at concentrations that are less than the report of waterbodies in Ondo, Nigeria [17]. Each one of these substances can act as goitrogen; consequently, their combination might give a combine negative effect on iodine metabolism of the body of the consumers, and they are portending for water pollution [4], [17], [22], [23]. The Table 4-5 shows the levels of iodine/ goitrogenic ratio of some goitrogens, therewith, only few recorded values that are greater than 1, that is 6.15 and 5.00 for perchlorate, 6.000, 1.5375, and 16.6666 for bromide, and 1.5625 for nitrate.

Table 6. Evaluated iodine/Goitrogenic factors (calcium, phosphate, and magnesium) in water from certain schools in Kebbi, Nigeria

Name of school	CALCIUM	MAGNESIUM	PHOSPHATE
School A	0.01490	0.120	4.00000
School B	0.027333	0.02563	2.05000
School C	0.07353	0.11363	3.57143

In table 6, there are the iodine/goitrogenic ratio for three useful nutrients, calcium, magnesium, and phosphate. All the values of phosphate recorded are above 1. Salawu et al [17] reiterated that iodine uptake is reflected in the iodine/ goitrogenic. Iodine/ goitrogen ration balance is a rising factor that is been used by m any to illustrate the balance of iodine in relation to the intake of substances. For example, iodine/ bromide ratio is related to the iodine supply, a study examined the impact of exogenous bromide intake on iodine bioavailability in rats; therewith, animals with lower iodine/bromide ratio have more tendency to show iodine deficiency. Implying that, animals with sufficient iodine concentration/ intake have higher iodine/bromide ratio. When bromide gets into the body, it displaced iodine and combine with thyroid gland as thyroglobulin leading to formation of brominated thyroxines instead of the normal iodinated thyroxine [23]. In a similar study, it was echoed that, there was prevalence of iodine deficiency in children they observed due to the low iodine/goitrogen (thiocyanate) ratio caused by intake of goitrogens in food substances of the area. In that regards, iodine was competitively inhibited by the action of thiocyanate overload. Therefore, it implies that people who have low iodine/ goitrogen ration and have low iodine intake are more prone to iodine problems. For people to secure themselves against iodine deficiency or problems, they need to shun goitrogenic foods sources and take in sufficient amount of iodine [24]–[26].

Iodine is among the essential elements needed by the body and has to be taken up through food or water; therefore, the water consumed y school-aged children s important or providing quotas of iodine and nutrients or the health and development of the youngsters [4], [27]. Iodine from water or any other source taken up by humans is essential for making thyroid hormones. Lack of thyroid hormones especially in youngsters lead to diverse physiologic, morphologic, and biochemical problems [28] more pronounced in children (including school-aged ones) and currently about 1.2 billion people of the world battle with them; and half of the world population experience one or more form of iodine problem [28] 1/3 of school children

are supposed to be affected. Problems due to iodine are many, for instance, brain damage, low birth weight, deafness, miscarriage, diminished labor, diminished learning, growth delay, goiter, hyperthyroidism, hypothyroidism, reduced intellect, etc. Therefore, a worldwide practice to approach iodine problems is uptake of iodine through water, food, etc. However, the uptake has continuously been marred by presence of goitrogens (chemicals causing goiter by replacing iodine against its useful activities) [28]. That is why level of iodine and goitrogenic factors were measured in drinking water used by school-aged children in some secondary schools in Birnin Kebbi Local Government Area, Nigeria. And the results show that, there exist goitrogens present in the drinking water of school children, and in turn the water yield its quota of goitrogens that could elicit iodine problems among the consumers over a chronic exposure [25], [28], [29]. Thus, all stakeholders, including governments should work-out ways to provide qualitative water to schools for the health, growth, development and proper learning of school children as direct investment for the future of the country.

4 Conclusion

Iodine and goitrogen contents in water consumed by youngsters is paramount method of monitoring the pollution of drinking water and the possible problems that could arise due to iodine metabolism lesion in a region characterized with water issues and regarded as goiter region. Therefore, this study has revealed that the water used in the studied schools contains goitrogens that can contribute to the interference in iodine metabolism and leading to consequent harmful effects on youngsters.

We can restate that, all stakeholders, more pertinently, governments should work-out ways to provide qualitative water to schools for the health, growth, development and proper learning of school children as direct investment for the future of the country.

More efforts should be geared to encourage routine monitoring of water for goitrogens to make proper policies in the region that safeguard public nutrition and public health.

References

[1] O. Z. Wada, D. B. Olawade, E. O. Oladeji, A. O. Amusa, and E. O. Oloruntoba, "School water, sanitation, and hygiene inequalities: A bane of sustainable development goal six in nigeria," *Canadian Journal of Public Health*, vol. 113, no. 4, pp. 622–635, 2022.

[2] A. Kasarawa, I. Salau, and R. Aliyu, "Microbiological quality of non-registered table water sold in sokoto metropolis northwestern nigeria," *World Journal of Advanced Research and Reviews*, vol. 6, no. 3, pp. 007–011, 2020.

[3] A. A. Mensah, D. Adei, G. Kuubagr, S. O. Duah, and M. O. Asibey, "Operation and sustainability of water, sanitation and hygiene (wash) in schools: Evidence from a vulnerable and deprived area in ghana," *Cogent Public Health*, vol. 9, no. 1, p. 2 140 478, 2022.

[4] E. Ibitoye, Y. Dabai, and L. Mudi, "Evaluation of different drinking water sources in sokoto north-west nigeria on performance, carcass traits and haematology of broiler chickens.," 2013.

[5] A. Rahman, I. Jahanara, and Y. N. Jolly, "Assessment of physicochemical properties of water and their seasonal variation in an urban river in bangladesh," *Water Science and Engineering*, vol. 14, no. 2, pp. 139–148, 2021.

[6] A. Abdulhamid, I. Fakai, I. Sani, F. Bello, and E. Solomon, "Evaluation of ground water quality in kalambaina community, wammako local government area, sokoto state," *Equity Journal of Science and Technology*, vol. 1, no. 1, pp. 104–109, 2013.

[7] A. Isah, I. Saidu, K. Bello, S. Garba, and S. Umar, "Assessment of physicochemical properties of groundwater sources from some selected areas in sokoto metropolis, nigeria," *International Journal of Innovativ e Research & Development*, vol. 5, pp. 244–250, 2016.

[8] U. Aliyu, M. H. Yankuzo, and A. Ishaka, "Determination of selected heavy metals in drinking water commonly used in main campus usmanu danfodiyo university sokoto," *IOSR Journal of Applied Chemistry*, vol. 13, no. 2, pp. 18–21, 2020.

[9] Y. Sarkingobir, S. Sambo, and U. Tukur, "Bacterial quality assessment of drinking water for layer chicken managed under battery cage and deep litter systems from sokoto metropolis, nigeria," *Journal of Applied Sciences and Environmental Management*, vol. 24, no. 1, pp. 97–103, 2020.

[10] S. Wali, M. Gada, I. Hamisu, *et al.*, "Evaluation of shallow groundwater in rural kebbi state, nw nigeria, using multivariate analysis: Implication for grou ndwater quality management," *MOJ Eco Environ Sci*, vol. 7, no. 3, pp. 65–75, 2022.

[11] M. Raji, Y. Ibrahim, and J. Ehinmidu, "Physico-chemic al characteristics and heavy metal levels in drinking water sources in sokoto metropolis in north-western nigeria," *Journal of Applied Sciences and Environmental Management*, vol. 14, no. 3, 2010.

[12] G. N. Doku and E. A. Bortey, "Iodine levels in brands of salt on the markets of accra, ghana," *Ghana Medical Journal*, vol. 52, no. 3, pp. 163–167, 2018.

[13] M. H. Zia, M. J. Watts, A. Gardner, and S. R. Chenery, "Iodine status of soils, grain crops, and irrigation waters in pakistan," *Environmental Earth Sciences*, vol. 73, pp. 7995–8008, 2015.

[14] Y.-l. Lu, N.-j. Wang, L. Zhu, *et al.*, "Investigation of iodine concentration in salt, water and soil along the coast of zhejiang, china," *Journal of Zhejiang University SCIENCE B*, vol. 6, pp. 1200–1205, 2005.

[15] T. Yahaya, V. Doherty, O. Akinola, and A. Shamsudeen, "Heavy metal profiles and microbial counts of selected sachet water brands in birnin kebbi metropolis, nigeria," *Ife Journal of Science*, vol. 21, no. 1, pp. 229–234, 2019.

[16] V.-U. Hernando, B.-P. Anilza, and S.-T. C. Hernán, "Journal of thyroid disorders & therapy," 2015.

[17] S. Salawu, O. Adu, and A. Akindahunsi, "Distribution of iodine and some goitrogens in two selected water bodies in ondo-state, nigeria," *Global Journal of Pure and Applied Sciences*, vol. 10, no. 1, pp. 161–164, 2004.

[18] R. Fuge and C. C. Johnson, "Iodine and human health, the role of environmental geochemistry and diet, a review," *Applied Geochemistry*, vol. 63, pp. 282–302, 2015.

[19] A. Umar, A. Labbo, A. Sumayya, *et al.*, "Effects of some goitrogens on iodine distributions in pipe-borne water, borehole water and well water of sokoto state, nigeria," *International journal of Pure and Applied Science*, vol. 21, no. 9, pp. 29–40, 2021.

[20] A. A. Oladejo, M. A. Okesola, A. S. Oyerinde, K. F. Jaiyesimi, and J. A. Kolawole, "Evaluation of goitrogenic content of common vegetables in south west nigeria," *Asian Food Science Journal*, vol. 4, no. 1, pp. 1–7, 2018.

[21] L. Lin, S. St Clair, G. D. Gamble, *et al.*, "Nitrate contamination in drinking water and adverse reproductive and birth outcomes: A systematic review and meta-analysis," *Scientific Reports*, vol. 13, no. 1, p. 563, 2023.

[22] M. Bouga, F. Cousins, M. Lean, and E. Combet, "Influence of goitrogenic foods intake on thyroid functions in healthy females of childbearing age with low habitual iodine intake," *Proceedings of the Nutrition Society*, vol. 74, no. OCE1, E39, 2015.

[23] S. Pavelka, "Metabolism of bromide and its interference with the metabolism of iodine," *Physiological research*, vol. 53, S81–90, 2004.

[24] I. Taga, V. A. S. Oumbe, R. Johns, M. A. Zaidi, J. N. Yonkeu, and I. Altosaar, "Youth of west cameroon are at high risk of developing idd due to low dietary iodine and high dietary thiocyanate.," *African Health Sciences*, vol. 8, no. 4, pp. 227–233, 2008.

[25] S. Shehu and A. U. Kurya, "Nutritional, antinutritional and therapeutic potentials of solanum incanum linnaeus fruit cultivated in sokoto, northern nigeria," *Nigerian Journal Pure and Applied Science*, vol. 32, no. 2, pp. 3462–3468, 2019.

[26] A. Hamza, A. M. Gumi, A. A. Aliero, A. Umar, Y. Sarkingobir, and U. Tambari, "Potential of neem leaves on preservation of selected elemental compositions in two tomato cultivars from sokoto, nigeria," *Journal of Bioresources and Environmental Sciences*, vol. 2, no. 1, pp. 15–20, 2023.

[27] N. Khan, S. T. Hussain, A. Saboor, N. Jamila, and K. S. Kim, "Physicochemical investigation of the drinking water sources from mardan, khyber pakhtunkhwa, pakistan," *International journal of physical sciences*, vol. 8, no. 33, pp. 1661–1671, 2013.

[28] F. Azizi, H. Delshad, P. Mirmiran, L. Mehran, and M. Tohidi, "Iodine status and thyroid parameters of pregnant women living in an iodine sufficient area," *Archives of Food and Nutritional Science*, vol. 5, no. 1, pp. 001–006, 2021.

[29] Y. Sarkingobir, A. A. Lawal, and Z. Bello, "Covid-19: Causing increased pollution of waterbodies by plastics and consequent effects," *Journal of water Pollution and Purification Research*, vol. 8, no. 1, pp. 20–24, 2021.

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