

# Processing Halogen Compounds into Water Containing Iodine

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*Received May 9, 2024; Revised August 25, 2024; Accepted September 15, 2024*

## Cite This Paper in the Following Citation Styles

(a): [1] Semuel Piter Irab, Maxsi Irmanto, Apriyana Irjayanti, Marlina Flassy, Evi Sinaga, Agus Zainuri, Oscar Oswald Wambrauw, Rosmin Mariati Tingginehe, "Processing Halogen Compounds into Water Containing Iodine," *Universal Journal of Public Health*, Vol. 12, No. 6, pp. 1099 - 1113, 2024. DOI: 10.13189/ujph.2024.120607.

(b): Semuel Piter Irab, Maxsi Irmanto, Apriyana Irjayanti, Marlina Flassy, Evi Sinaga, Agus Zainuri, Oscar Oswald Wambrauw, Rosmin Mariati Tingginehe (2024). *Processing Halogen Compounds into Water Containing Iodine*. *Universal Journal of Public Health*, 12(6), 1099 - 1113. DOI: 10.13189/ujph.2024.120607.

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**Abstract** Compound Halogens are very important in the field of nutritional science. One very important element is iodine. However, other elements such as Fluorine, Chlorine, Bromine, Astatine, and other elements in halogen compounds are very important for human health. The research aims to determine the phenomenon of halogen water sources, and the quality of halogen water through laboratory examinations, and to carry out experimental interventions on halogen water stored in the refrigerator and not stored in the refrigerator. The research uses phenomenological methods, laboratory examinations, and experimental interventions. The results of the research show that the mining area is a source of halogen water, in summer the quality of halogen compounds is better than in the rainy season, Papuan people consume halogen compounds, and laboratory examinations show that halogen water after processing has better quality than before processing, inorganic and organic chemical examinations show that halogen water after processing has better quality than before processing, halogen water processed and stored in the refrigerator has good quality, halogen water that is not stored in the refrigerator has low quality. Conclusion: native Papuans consume halogen water, halogen water after processing has better quality than unprocessed, laboratory tests show that halogen water after processing is better than before processing, and

halogen water stored in the refrigerator is better than not stored in the refrigerator.

**Keywords** Halogen Water Process, Contains Iodine

## 1. Introduction

Group VIIA elements, commonly known as halogens are widely recognized as the most reactive elements [1], leading to their inability to exist in a free state in nature [2]. Several reports have shown that the term 'halogen' originates from the name halo genes, which means salt forming [3]. In addition, halogen compounds comprise non-metallic elements, including Fluorine (F<sub>2</sub>), Chlorine (Cl<sub>2</sub>), Bromine (Br<sub>2</sub>), Iodine (I<sub>2</sub>), and Astatine (At<sub>2</sub>) [4, 5, 6]. According to Samuel Piter Irab and Rosmin M. Tingginehe, these compounds are also called halogen nutrients (salty cloudy water) and can be obtained from the soil and the surface of the earth, leading to their characteristic salty taste [7]. Salty cloudy water gives taste, strength, health, happiness, and longevity to animals and humans [8]. Halogen compounds have also been reported to be sparsely distributed on the earth's surface [8], causing instability and quick sublimation [9] when

exposed to sunlight, lamp light, and hot air [10]. This indicates that there is a pressing need to preserve the quality of the constituent elements [11] through effective processing, storage, and distribution [12, 13].

In line with previous studies, the proper processing of halogen compounds is essential to safeguard human health, [14], particularly maternal and child health [15]. In addition, the process must be carried out carefully, as the constituent elements [16] have the potential to turn into other elements that are harmful to human health [17, 18]. Environmental factors also need to be considered, including the presence of trees growing on halogen springs, which keeps the air temperature cool [15]. Several reports have shown that environmental pollution [19] from household waste, manufacturing waste, hospital waste, pest control pesticides, and human and animal feces can greatly affect the quality of springs [20, 21].

According to several studies, halogen compounds play an essential role in the health sector due to their benefits. For example, fluoride salts are often added to toothpaste to prevent tooth decay [22] [23], while chlorine is typically used as a disinfectant in drinking water and swimming pools [24]. In addition, sodium chloride is used as table salt for cooking food [25] and sodium bromide serves as a brain nerve sedative [26]. Iodine has been shown to have the potential to prevent goiter [27], improve brain development or intelligence of children [28], reduce creatine in children [29], increase child growth [30], and prevent mental disorders in children [31]. Astatine has similar benefits as iodine, such as preventing goiter [32], as well as the ability to kill tumor cells [27, 32].

The use of halogen compounds in the health sector is significant, with 60% of adults and 94% of children benefiting from water containing fluorine [33]. In addition, in the United States the use of chlorine in drinking water has had a positive impact on reducing pathogenic microorganisms, namely cholera (90%), typhus (80%), and amoebic dysentery (50%) [34, 35]. Specifications for bromine in wastewater processing into drinking water include maintaining a pH range of 6.0–8.5, with concentrations of hydrogen bromide ranging from 100% to 57.0%, and OBr- ranging from 0% to 43.0% [36]. For iodine, specifications for drinking water involve a pH range of 5–8, with I<sub>2</sub> concentrations ranging from 90% to 12%, and HIO concentrations ranging from 1% to 88% [36]. Moreover, astatine (<sup>211</sup>At) at an injection dose of 2.25% can serve as an anti-tumor therapy for pancreatic cancer when given intravenously [37].

Several studies have shown that freshwater treated with halogen compounds often lacks a salty taste [15]. However, halogen compounds typically have a salty and slightly bitter taste and are not sourced from seawater [7], but from coal mining areas [15]. Water is widely known as a necessity for human life due to its role in maintaining the body's health [38]. Despite the potential, reports on the quality of springs water in Karang and Kaliorang subdistricts, East Kutai Regency, Indonesia, have shown

contamination by organic materials [39]. The concentration of organic compounds and ammonia in Drinking Water Companies (DWC) has continued to increase due to industrial and domestic waste pollution [40]. To mitigate this challenge, the levels of chloride and phosphate in the water samples have been tested and reported to meet the health requirements for the living needs of the people in Tobasa Regency, Indonesia [41]. Various drinking water treatments for human health have also been carried out by several reports. However, in this study, halogen compounds from salt springs in mining areas were processed into water containing iodine for human health drinks.

## 2. Materials and Methods

The study design used three methods, namely phenomenology, laboratory examination, and intervention experiments.

### 2.1. Phenomenology Study Design

The focus of the phenomenological approach is to understand, describe, analyze data in depth, interpret, complete, and structure the uniqueness of halogen water consumed by the ancestors of indigenous Papuans in Papua Province, Indonesia, apart from that, wild animals in Papua Province also consume halogen compounds. The detailed phenomenological study explains the spring sources of halogen compounds, the quality of halogen compounds in the summer and rainy seasons, and the history of Indigenous Papuans consuming halogen compounds before iodine salt was introduced by the Dutch and Indonesian governments from 1855 to 2023. Printed books and internet media explaining the properties of halogen compounds revealed their use by native Papuans for improving health status [42].

### 2.2. Laboratory Examination Study Design

Examination of halogen water samples before and after processing was carried out at the Health Laboratory Dok II Jayapura, Papua Province, Indonesia. The types of laboratory tests were physical/field, inorganic chemical, organic chemistry, disinfectant, and water microbiological examinations.

The examination consists of two stages. The first stage before processing is that the halogen compound is taken from the halogen spring, and immediately carried out a laboratory examination, the time for collection and laboratory examination is less than two hours. The first stage of examination is that the halogen water is not filtered with gauze, is not processed, and is immediately carried out by laboratory examination. The second stage after processing is that the halogen compound is taken from the halogen spring, filtered with gauze, stored in a plastic

bottle, the surface of the plastic bottle is closed, stored in the refrigerator freezer for 6 days, and on the 6th day a laboratory examination is carried out.

**2.3. Intervention Experiment Study Design**

The iodine test was a reagent used by health workers to determine the level of the element in salt circulating in the market. The result of the Iodine test reagent when applied to salt exhibited a color alteration, specifically turning purple or blue, and this alteration signified the presence of iodine in the salt. Meanwhile, when the reagent was applied and there was no change in color, the salt lacked iodine, and the test was officially recognized by both the Food and Drug Supervisory Agency (FDSA), and the Ministry of Health of Indonesia. This held significance for evaluating iodine content in all salt products circulating in the market [15].

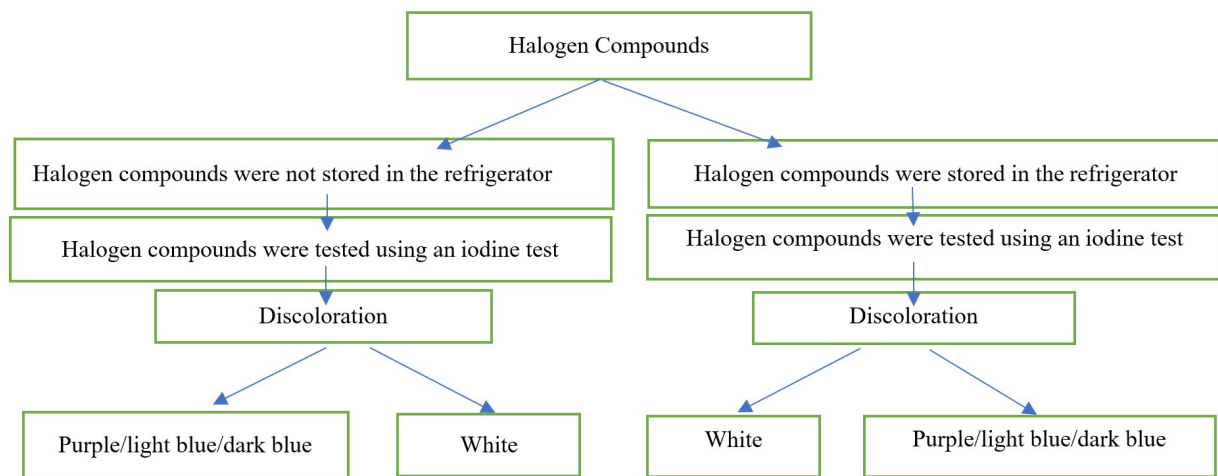
The process of processing halogen compounds into water containing iodine using an intervention experimental study design was divided into 2 parts, namely (1) halogen compounds intervention experiment packaged in 6 plastic bottles with a size of 120 milliliters per bottle and stored in the refrigerator freezer, (2) halogen compounds intervention experiment packaged in 6 plastic bottles with a size of 120 ml per bottle, and the bottle cover was opened

and not stored in the refrigerator freezer. Furthermore, an iodine level test was carried out on refrigerated and non-refrigerated halogen compounds [43].

Experiments were carried out for 1 to 6 days, and the results were determined using the iodine test reagent. A purple or blue color change indicated the presence of iodine and when no color change occurred, the compound retained its white color, signifying the absence of the element. An overview of the stages of the intervention trial is presented in figure 1 above [44, 15].

**2.4. Inclusion and Exclusion Criteria**

This study included spring water consumed by domesticated cattle or forest animals, as well as indigenous Papuans before the introduction of iodized salt, and the samples were directly collected from the spring. Conversely, springs that were not used for drinking or cooking purposes before the introduction of iodine salt were excluded from spring. Experimental samples were also only exclusively collected from spring that met the specified criteria. This study underwent a thorough Ethics Review and received approval from the Ethics Committee of Cenderawasih University, with a registry number of 070/KEPK-FKM UC/2023, granted on May 25th, 2023.



Source, Semuel Piter Irab Concept, 2023 (Zat Gizi Book, 2023) [15]

**Figure 1.** Test for iodine level using the iodine test reagent [15]

### 3. Results and Discussion

#### 3.1. Phenomenology Variables

##### 3.1.1. Source of Halogen Compound Spring

The source of spring water was the elements hydrogen and oxygen forming H<sub>2</sub>O compounds that were found in the soil and came out to the surface of the earth [45]. The water that came out in certain places was called groundwater springs, rocky mountains, and sand [46]. Halogen compounds also originated from spring water, but springs of halogen compounds differed significantly from freshwater springs [7, 47]. In addition, freshwater springs could be found in many different quantities [48], while springs containing halogen compounds were exceedingly rare on the earth's surface [15].

The halogen compound springs were sourced in mining areas and tasted salty or contained salt [49]. Water discharge from these springs was limited, and the salty taste was only detected in the spring water, however, it disappeared once the water moved away from the spring [7, 15]. This proved the rapid dissipation of halogen compounds in hot air, forming other compounds [50], and to determine the source of the halogen compound springs, various forest animals were observed drinking the water during the summer [15]. These animals included birds, deer, kangaroos, rats, snakes, wild boars, butterflies, bees, and other species [7].

The presence of halogen compounds in spring water imparted an exceptionally salty taste [1, 4], rendering it unpalatable for forest animals, and this indicated that the spring source of the halogen compound was dangerous for the life of forest animals and human consumers [15]. Rapid evaporation of halogen compounds from the springs in intense sunlight [4, 5, 7] resulted in the release of high-pressure gas, which led to the demise of earthworms, and other microbes, and the desiccation of surrounding vegetation [15] (Note: a total of 5 drops of halogen using a syringe on White HVS paper, reacted with 2 to 3 drops of iodine reagent [15]).

##### 3.1.2. Summer and Rain

The rainy season and summer needed to be considered because individuals affected the quality of drinking water [38], including spring water containing halogen compounds [7]. Good springs for drinking water were springs that did not contain germs [39], and in summer, the water that came out with halogen was pure, not mixed with rainwater, not mixed with rotting leaves, forest animal waste, or water-soluble bacteria [15]. In addition, it was not contaminated with chemicals [40], while the quality of halogen compounds taken in summer was very good compared to the rainy season [7].

The halogen compound spring water that came out was truly pure, namely coming from the disposal of liquid coal in the form of salt water, which was very good for

improving the health of forest animals and humans [1, 15]. The time for taking halogen compounds was determined by the half-life of each element [4], and the element astatine had a half-life of 8.3 hours, iodine had a half-life of 8 days, bromine had a half-life of 57.036 hours, while the elements chlorine and fluorine had a greater half-life [15, 51, 52]. Based on the half-life of the elements of halogen compounds which differed from one element to another, the time for taking halogen compounds must be estimated properly for the quality of halogen compounds to remain good [7, 50]. In addition, at the stage of taking halogen compounds, the processing process up to the storage stage must be cold, and the time required for storage was less than 8 hours [7, 15, 53].

The element that was measured was astatine, which had a short half-life, and this characteristic ensured that other elements in halogen compounds were not lost or evaporated due to exposure to sunlight and hot air temperatures [7, 15, 54]. Optimal times for collecting halogen compounds were at dawn or between 1 pm and 5 am when dew from the sky settled on the earth's surface and air humidity was high. This period was particularly suitable for collecting halogen compounds from springs [7, 15, 55].

##### 3.1.3. History of Indigenous Papuans Consuming Halogen Compound

The study on halogen compounds conducted from 2013 – 2022 proved that many springs of halogen compounds were found in certain areas in Papua Province, Indonesia [15]. Springs were a source of life for humans [56], however, springs of halogen compounds were an important source of life for indigenous Papuans who lived far from seawater [7]. Before the introduction of iodized salt, indigenous Papuans used halogen compounds for cooking food [15], and this happened before 1855 when 2 missionaries (Carl Willem Ottow and Johann Gotlob Geissler) from the Netherlands and Germany entered New Guinea with the teachings of Christianity. Furthermore, it predated the Indonesian government's presence on the island of Papua in 1962 [57].

Halogen compounds were used by indigenous Papuans as a family dish, but also to enhance nutritional status [7, 15], and this was referred to as the condition of the body as a result of the food intake consumed by humans to improve health status [58], body endurance [59], prevention of infectious diseases [60], promoting growth and development [61], and extending life expectancy [62]. Consuming balanced and nutritious food was crucial for maintaining good health in humans [7].

In the days of the ancestors of the native Papuans [63], individuals consumed food naturally, and this food did not contain preservatives [64]. The foods commonly consumed by the ancestors of Indigenous Papuans were sago, sweet potatoes, taro, bananas, vegetables, fruit, fish, and sago worms [65, 66]. All of this had been provided by nature [7],

and this natural food was very important for improving the nutritional status and health of the ancestors of Indigenous Papuans in the past [15].

Halogen compounds, considered vital for enhancing nutritional status, endurance, and overall health, were widely consumed by the ancestors of indigenous Papuans who resided far from seawater [7]. Halogen nutrients (halogen compounds) were mostly used whenever cooking and serving food to family members, and this also played a vital role in enhancing food taste. In addition, certain fruits and vegetables were soaked in halogen compounds, and eaten by family members. The above figure 2 was a photo of a spring containing halogen compounds that the ancestors of Indigenous Papuans used for consumption [15].

Consumption of halogen nutrients made a difference in better nutritional status, thus, pregnant women, breastfeeding mothers, babies, toddlers, adults and the elderly did not experience halogen nutrient deficiencies in Papua Province [7]. This proved that those who consumed halogen nutrients had better nutritional status, but the ancestors of Indigenous Papuans who consumed fewer halogen nutrients had low nutritional status [15]. The halogen nutrients were rich in the elements Fluorine ( $F_2$ ), Chlorine ( $Cl_2$ ), Bromine ( $Br_2$ ), Iodine ( $I_2$ ), and Astatine ( $At_2$ ) [4, 50, 51, 52, 53, 54, 55]. The elements within these halogen compounds served as a crucial nutritional source for the indigenous Papuans in Papua Province, contributing to their long life expectancy. Moreover, maternal and child morbidity and mortality rates were significantly low [7]

An essential aspect of halogen substances that proved beneficial for the health of native Papuans, involved their consumption of a variety of locally available foods from yards, gardens, hamlets, forests, rivers, lakes, and ponds [15]. The consumption of diverse food items containing

halogen during family meals had a positive impact on improving the nutritional status of pregnant women, breastfeeding mothers, infants, and toddlers [7]. However, the consumption of a wide range of foods led to a decline in nutritional status [67, 68]. Excessive intake of halogen nutrients (halogen compounds) resulted in symptoms such as nausea, vomiting, heart palpitations, and hypertension [7]. Halogen compounds were nutritional substances that were unstable and prone to rapid decomposition or transformation into other substances. Therefore it was necessary to process these compounds properly to prevent the loss of essential elements within halogen. An image of halogen nutrients (halogen compounds) was provided for visual reference[15].

Halogen compounds were essential nutrients for the health of pregnant women, nursing mothers, and children under five [7]. This compound was a strong oxidizer in metabolic processes to improve the nutritional status of pregnant women, breastfeeding mothers, children under five, and other age groups in Papua Province, Indonesia [15]. In addition, halogen compounds could function as immune substances to provide the body's resistance to attacks by infectious diseases [7]. Groups vulnerable to infectious diseases, including pregnant women, breastfeeding mothers, and children under five could have their health status improved by consuming halogen compounds [15]. Based on the periodic system of elements, halogen compounds were in group VIIA [69], and the element Fluorine had an atomic number of 9 with a mass of 18, the element Chlorine had an atomic number of 17 with a mass of 35, the element Bromine had an atomic number 35 with a mass of 79, the element Iodine had an atomic number 53 with a mass of 126, and the element Astatine had an atomic number 85 with a mass of 209. The total mass of the halogen compounds was 467 [70] (figure 3).



Note: That Indigenous Papuans soaked the inner fibers of banana trees in a halogen spring, and soaked banana fiber for up to one week. Furthermore, it went home to Honay's house and was consumed for days by family members [15].

**Figure 2.** Halogen Spring in Papua Province, Indonesia

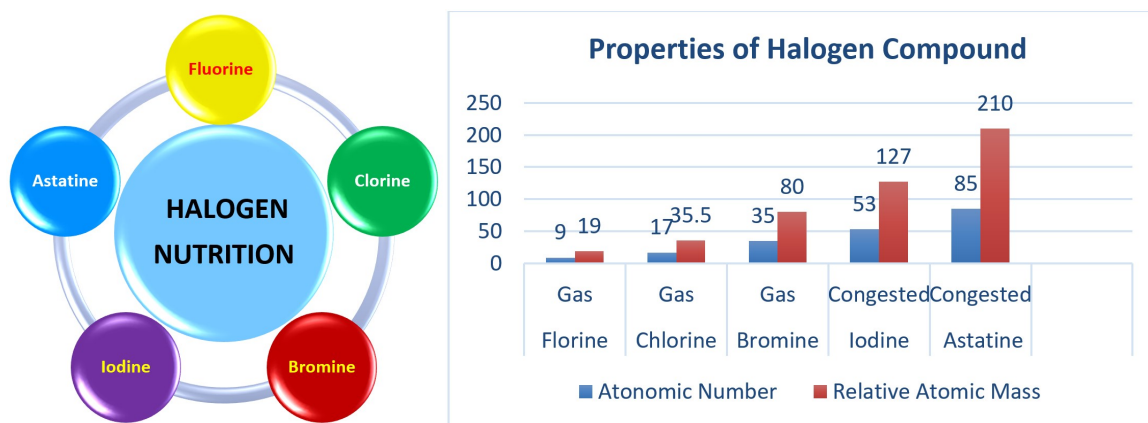


Figure 3. Halogen Nutrition and Properties of Halogen Compounds [7, 15, 54, 55]

### 3.2. Variables Laboratory Examination

#### 3.2.1. Physical/Field, Disinfectant, and Water Microbiology Examination

Field physical examination laboratory tests, on halogen water included quality standards such as odorless, tasteless, temperature  $\text{Air} \pm 3$ , color 15 TCu, turbidity 5 NTu, and dissolved solids 500 (Mg/L). Based on the laboratory results, the odor quality standard of halogen water before processing met health requirements for human consumption. However, taste, temperature, color, turbidity, and dissolved solids did not meet the health requirements of drinking water quality standards (Table 1).

Laboratory results also showed that halogen water after processing had quality standards for odor and turbidity, which met health requirements for humans. However, taste, temperature, color, and dissolved solids did not meet the health requirements of drinking water quality standards (Table 1).

Laboratory tests revealed that the quality standard for halogen water before chlorine treatment was 1.24 mg/L, while a value of 1.45 mg/L was obtained after processing. In addition, chlorine met the standard requirements for drinking water quality for humans, namely  $< 5$  mg/L. This indicated that halogen water in Genyem Kecil Village used for cooking food before the introduction of iodized salt fulfilled the health requirements (Table 1).

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#### 3.2.2. Inorganic and Organic Chemical Examinations

Laboratory tests were conducted on halogen water in the field of inorganic chemistry, and before processing, the halogen water quality standards were examined. The laboratory results indicated that the water met the quality standards for drinking water health requirements, namely pH, Fluoride (F), Total Hardness ( $\text{CaCO}_3$ ), Nitrate as ( $\text{NO}_3 - \text{N}$ ), Nitrite as ( $\text{NO}_2 - \text{N}$ ), Sulfate ( $\text{SO}_4$ ), Iron (Fe), Cadmium (Cd), Chromium (Cr Valence 6), Manganese (Mn), Lead (Pb), Copper (Cu), Zinc (Zn). However, it was found that halogen water before processing did not comply with the quality standards for drinking water health requirements, specifically Ammonia as ( $\text{NH}_3\text{-N}$ ), and Chloride (Cl) (Table 1).

After processing, the quality standards for halogen water were evaluated through laboratory results. The results indicated compliance with health requirements for drinking water for humans, including pH, Chloride (Cl), Fluoride (F), Nitrate as ( $\text{NO}_3 - \text{N}$ ), Nitrite as ( $\text{NO}_2 - \text{N}$ ), Sulfate ( $\text{SO}_4$ ), Iron (Fe), Cadmium (Cd), Chromium (Cr Valence 6), Manganese (Mn), Lead (Pb), Copper (Cu), and Zinc (Zn). However, it was found that halogen water after processing did not meet the quality standards for healthy drinking water in terms of Ammonia ( $\text{NH}_3\text{-N}$ ), and Total Hardness ( $\text{CaCO}_3$ ). In addition, it was important to note that the examination of certain inorganic chemicals, namely Cyanide (CN), Aluminum (Al), Arsenic (As), Mercury (Hg), and Selenium (Se) was limited, and no laboratory results were available for these substances (Table 1).

Laboratory tests were conducted on halogen water to assess its organic chemistry, focusing on halogen water quality standards both pre and post-processing. The results revealed that organic substances, represented by ( $\text{KMnO}_4$ ) complied with human drinking water quality standards. These findings demonstrated that the organic substances ( $\text{KMnO}_4$ ) present in halogen water pose no health and were suitable for human consumption. Specifically, laboratory results indicated a concentration of 6.3 Mg/L before processing, which decreased to 2.12 Mg/L after processing, well below the quality standard of 10 Mg/L (Table 1).

**Table 1.** The Physical/Field, Disinfectant, Water Microbiology Examination, Inorganic Chemistry Examination, Organic Chemistry Examination, Before Processing And After Processing Halogen Water

No	Parameter	Unit	Before Processing		After Processing		Method Specifications
			Quality standards	Test results	Quality standards	Test results	
<b>A Physics/Field Examination</b>							
	Smell	-	Odorless	Odorless	Odorless	Odorless	SNI 06-2413-1991
	Taste	-	Tasteless	Taste	Tasteless	Taste	SNI 06-2413-1991
	Temperature	0 C	Air Temperature ±3	28.7	Air Temperature ±3	28.7	SNI 06-6989.23-2005
	Color	TCu	15	145.0	15	436.0	SNI 06-2413-1991
	Turbidity	NTu	5	23.0	5	4.50	SNI 06-6989.25-2005
	Dissolved Solids (TDS)	mg/L	500	11840.0	500	10150.0	SNI 06-2413-1991
<b>B Disinfectant</b>							
	Chlorine	mg/L	5	1.24	5	1.45	USEPA Method 8021
<b>C Water Microbiology</b>							
	Fecal coli	MPN/100 ml	0	9	0	0	IKM/5.4.9001-01/BLK/PAPUA (Double Tube)
	Coli form	MPN/100 ml	0	12	0	0	IKM/5.4.9001-01/BLK/PAPUA (Double Tube)
<b>D Inorganic Chemistry Examination</b>							
	pH		6.5-8.5	7.35	6.5-8.5	7.72	SNI 06.6989.11-2004
	Ammonia as ( NH <sub>3</sub> -N)	mg/L	1.5	36.0	1.5	64.0	USEPA METHOD 8038
	Chloride (Cl)	mg/L	250	496.0	250	135.0	SNI 6989.19: 2009
	Cyanide (CN)	mg/L	0.07	-	0.07	-	-
	Fluoride (F)	mg/L	1.5	0.10	1.5	0.30	USEPA METHOD 8029
	Total Hardness (CaCO <sub>3</sub> )	mg/L	500	473.0	500	527.0	2012 Standard Method, Section 2340.C
	Nitrate as (NO <sub>3</sub> - N)	mg/L	50	9.50	50	6.40	Standard Method 2012, Section 4500-NO3. E
	Nitrite as (NO <sub>2</sub> - N)	mg/L	3	0.012	3	0.026	Standard Method 2012, Section 4500-NO2. B
	Sulfate (SO <sub>4</sub> )	mg/L	250	23.0	250	13.0	USEPA Method 8051
	Aluminum (Al)	mg/L	0.2	-	0.2	-	-
	Arsenic (As)	mg/L	0.01	-	0.01	-	-
	Iron (Fe)	mg/L	0.3	0.160	0.3	0.180	Standard Method 2005, Section 3500-Fe. B
	Cadmium (Cd)	mg/L	0.003	0.003	0.003	0.003	SNI 6989.16, 2009
	Chromium (Cr Valence 6)	mg/L	0.05	0.040	0.05	0.047	Standard Method 2012, Section 3500-Cr B
	Manganese (Mn)	mg/L	0.4	0.025	0.4	0.020	USEPA Method 8149
	Mercury (Hg)	mg/L	0.001	-	0.001	-	-
	Selenium (Se)	mg/L	0.01	-	0.01	-	-
	Lead (Pb)	mg/L	0.01	0.017	0.01	0.015	SNI 6989.8, 2009
	Copper (Cu)	mg/L	2	0.094	2	0.090	SNI 6989.6, 2009
	Zinc (Zn)	mg/L	3	0.042	3	0.050	USEPA Method 8009

Table 1 continued

E Organic Chemistry Examination						
Organic Substances(KMnO <sub>4</sub> )	mg/L	10	6.30	10	2.12	SNI 06-6989. 22-2004
Detergent as MBAS	mg/L	0.05	-	0.05	-	-

Note:

1. SNI (Indonesian Standart National) Method Specifications

2. Examination, Papua Regional Health Laboratory Center, Testing Laboratory. Jl. Health No. 28 RSUD II Jayapura Complex, tel. (0967) 5161946 – 5164779. Email: labkes.papua@yahoo.com.

3. Decree of the Minister of Health of the Republic of Indonesia Number: 492/MENKES/SK/IV/ 2010, April 19, 2010, Concerning: Drinking Water Quality Requirements.

### 3.3. Experimental Variables

The experimental variable involved reacting halogenated water with the iodine test reagent to determine the iodine content [15, 71, 72]. A color change indicated the presence of iodine, this proved that halogen water contained iodine [15, 73, 74]. When halogen water was reacted with the iodine test reagent then no color change occurred, which proved that halogen water did not contain iodine [15, 75, 76].

This method was used because health workers, including those in Indonesia, used the iodine test reagent to ascertain the iodine content in salt [72]. When the results of the iodine test were combined with the salt, the color changed to blue/purple, proving that the salt contained iodine, but when the color did not change, it indicated that the salt did not contain iodine [71, 74]. This equation was similarly applied to measure iodine in halogenated water [15, 73, 76]. Notably, both salt and halogen water shared characteristics such as a salty and slightly bitter taste, akin to seawater. During the experimental stages of halogen water filtration, samples were both refrigerated and non-refrigerated.

#### 3.3.1. Halogen Compounds Filtration

The filtration of halogen compounds was to prevent soil, sand, gravel, worm eggs, ants, E. coli, coliforms, bacteria, amoebas, and other objects that were not halogen compounds from entering the processing process [7, 15, 77, 78]. The study results showed that 25% of local springs

were found positive for fecal coliform, 91% of household drinking water samples were positive for fecal coliform, and 38% of households practiced unsafe water handling in Boloso Sore Woreda, Wolaita Zone Ethiopia [79]. Protection of spring water sources needed to be done properly, to protect the health of the people who drank them [80, 81].

Halogen compounds were compounds that were harmful to humans [15], and could easily react with other compounds to form new compounds [7]. Environmental pollution, factory waste, and household waste need to be controlled properly to protect water pollution sources and the quality of halogen water remained good [19, 20, 21]. The type of filtration used in this experiment was sterile cotton and sterile cloth to prevent small particles and bacteriology from entering halogen water [7, 15].

#### 3.3.2. Halogen Compounds Stored in the Refrigerator

In the experiment, the storage took place inside a refrigerator, specifically in the freezer compartment. Each of the 120 ml plastic bottles containing the compound was carefully covered with black tape to prevent any penetration of light from the refrigerator. The experimental procedure included subjecting one bottle to experimentation once daily, and this process was repeated for 6 consecutive days, resulting in each of the 6 bottles, labeled as A, B, C, D, E, and F, being experimented 6 times during this period (figure 4).



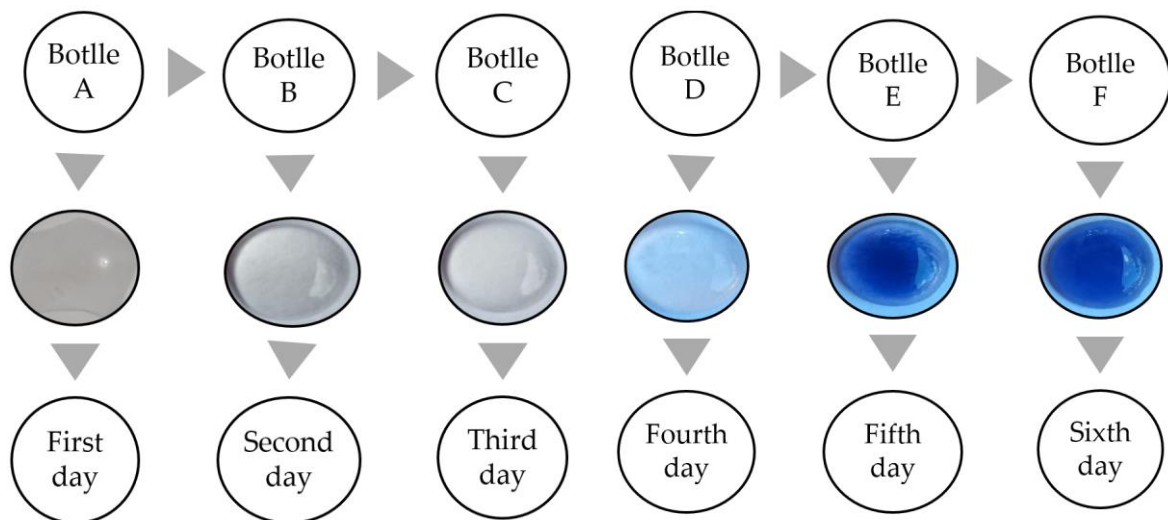
The bottle cover was tightly closed and NOT in contact with free air

The black tire plaque covered the entire surface of the plastic bottles



Stored in the refrigerator freezer

A B C D E F



Source, Samuel Piter Irab Concept, 2023 (Zat Gizi Book, 2023) [15].

Notes: The environment of the spring water source greatly influenced the quality of halogen. In the rainy season, the quality was very low, and in summer, the quality was very good, which was proven by all forest animals [15].

**Figure 4.** Halogen Compounds stored in the Refrigerator [15]

The experiment conducted in bottle A had been stored in a freezer and was acquired on the 1st of September 2023, at 06:00 AM local time in Papua. The compound originated from a natural spring, known as Genyem Kecil, located in Tabri Village, Nimboran District, Jayapura Regency. After a 12-hour assessment using an iodine test, bottle A exhibited no change in color. Specifically, the compound retained its original liquid-white color, indicating the absence of iodine, and there were no alterations in the blue or purple coloration, where the formation of yellow fluorine had not occurred. There was no evidence of gas pressure buildup in bottle A, and the distinctive, pungent odor characteristic of potent halogen was undetected. These 3 distinct observations collectively substantiate the

conclusion that the compound was not subjected to complete formation in bottle A.

On the second day of the experiment, which occurred on Saturday, September 2, 2023, bottle B was examined and stored in the refrigerator freezer for a total of 24 hours. Subsequently, halogen was subjected to an iodine test to assess its reactivity. The outcome of this evaluation showed an absence of any discernible color alteration in the compound in bottle B. Therefore, iodine was not subjected to proper formation in the bottle. The reaction yielded no indication of a purple or blue coloration following their interaction with the iodine test reagent.

On the third day of the week, September 3, 2023, the storage time for bottle C was 36 hours, and the

experimental results showed that there was no change in the color. Therefore, until the third day the compound in bottle C had not shown the presence of iodine according to a purple or blue color change.

Halogen compounds in bottle D were refrigerated for 48 hours. On the fourth day, which was Monday, September 4, 2023, an experiment was conducted to ascertain the presence of iodine, and the results showed that there was an absence of iodine in bottle D. This absence was attributed to the non-appearance of the characteristic yellow color, the incomplete formation of gas pressure, and the absence of the typically strong and sharp odor associated with halogen.

On Tuesday, September 5, 2023, an examination of a compound in bottle E was conducted following a storage period of 60 hours in a refrigerator freezer. On the fifth day of observation, transformations were observed in the bottles. These alterations included the development of a faint, pale yellow color, a discernible expansion of the bottle due to the buildup of gas pressure, and the presence of a highly pungent and sharp characteristic odor. Furthermore, the experimental results of the iodine test showed an alteration in color. The initial white color of the brass transitioned into a light purple color. This discernible shift indicated the formation of iodine on the fifth day, substantiated by the alteration in color from its original state to the observed purple.

Bottle F was subjected to a refrigeration freezer for 72 hours. On the sixth day, specifically Wednesday, September 6, 2023, the compound exhibited identical characteristics to those observed in bottle E. The results indicated that the compound subjected to the iodine test reagent changed color to purple. This substantiated the presence of the element, confirming the complete formation on the fifth and sixth days of the experiment.

The discovery of iodine elements in bottles E and F provided a clear insight into the formation process, which required a period ranging from 60 to 72 hours. Environmental factors played an important role in supporting the detection of iodine. Specifically, these factors included the exclusion of exposure to sunlight and refrigerator lights, the application of a light-blocking coating to the bottles, and the hermetic sealing of the lids to prevent any potential evaporation or contact with free air. These measures were the decisive factors contributing to iodine, as evidenced by the successful detection on the fifth and sixth days of the experiment.

### 3.3.3. Halogen Compounds not Stored in the Refrigerator

The purpose of the experiment was to ascertain the presence of iodine in a compound not subject to refrigeration storage. The experimental procedure included uncovering plastic bottle lids, allowing the compound to come into contact with ambient air, natural light, sunlight, and varying air temperatures. Additionally, bottles were not covered with any opaque material. The experiment spanned 6 days and used 6 bottles, each pre-filled with halogen compounds, as shown below.

On Friday, September 1, 2023, at 06:00 AM, Papua time, the compound was collected from Benggipkase spring, situated in Genyem Kecil Tabri Village, Nimboran District, Jayapura Regency, Papua Province, and subjected to an iodine test reagent after 12 hours. The experimental results showed that there was no observable alteration in the coloration in bottle A. Halogen in the open bottle, placed on a table, was subjected to rapid evaporation and depletion. The primary contributing factors to this phenomenon were elevated air temperatures, as well as exposure to sunlight and indoor lighting. Figure 5 below showed a detailed visualization of the experimental results.



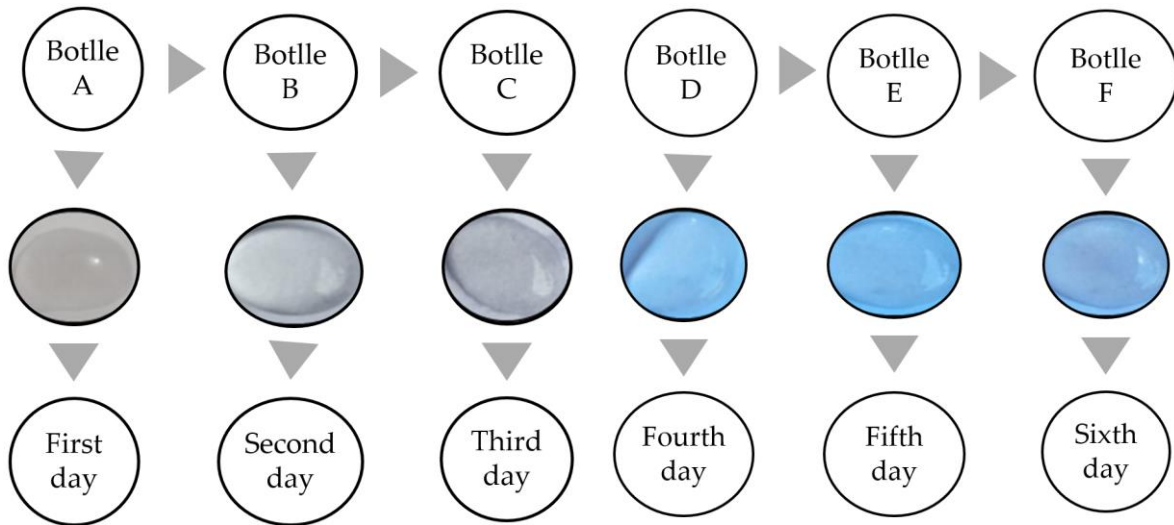
The bottle cap was NOT closed and the content was in contact with open-air

Black Tire Plaque DID NOT cover the entire surface of the Plastic bottles



NOT stored in the refrigerator freezer

A B C D E F



Source: Samuel Piter Irab Concept, 2023 (Zat Gizi Book, 2023) [15].

Notes: Properties of micronutrients of soil mineral salts. The mouth of plastic bottles was not closed, not covered with black tire plaque, exposed to sunlight and light, placed on the table, and in free contact with air. Evidence showed that the quality was very low, and no iodine element was found [15].

**Figure 5.** Halogen compounds were NOT stored in the refrigerator [15]

On the second day, September 2, 2023, an examination in bottle B was conducted. The storage duration was precisely 24 hours, and the container was positioned in an open environment. The results substantiated that halogen was subjected to negligible alteration, and this was evidenced by the faint yellow precipitated at the base of the bottle, a decrease in the characteristic odor, and a significant reduction in the gas pressure in bottle B. The results of the iodine test administered indicated no substantial variation. Specifically, multiple iodine tests performed exhibited no change in coloration, and this persisted as a slightly yellowish-white color, refraining from transitioning to purple.

On the third day of the week, September 3, 2023, bottle

C was examined. This bottle had been situated on a table in a well-ventilated room and the examination took place after a storage period of 36 hours. Alterations were observed, including the transformation of the yellow color into the sediment at the base of the bottle, a complete absence of gas pressure, a reduction in the characteristic odor, a diminished salty taste, and a transition in the color of the contained water from yellow to white. The results stemming from the iodine tests showed a lack of significance, where no discernible change in coloration had occurred. Therefore, iodine had dissipated due to factors such as evaporation, exposure to light and sunlight, and elevated air temperatures.

On the fourth day of the experiment, which took place

on Monday, September 4, 2023, the investigation was focused on bottle D, and the compound was subjected to a storage period of 48 hours. The observations exhibited resemblances to the characteristics of those preserved in bottle C. Halogen compounds existing in the unoccupied storage area showed signs of instability, leading to the facile transformation into alternative chemicals. This phenomenon underscored the influence of environmental variables such as humidity and storage techniques. Therefore, the compound stored in unoccupied storage space exhibited inferior quality.

On the fifth day of the experiment, which transpired on Tuesday, September 5, 2023, bottle E was examined after a storage period of 60 hours. The results stemming from the iodine test failed to manifest any alteration in coloration, signifying that the compound retained the white appearance. Halogen compounds exhibited analogous properties to those in C and D. From the empirical evidence, this study substantiated the assertion that halogen stored in unoccupied storage areas, devoid of any elemental iodine, remained unchanged during the experimental duration.

On the sixth day of the experiment, which occurred on September 6, 2023, the examination focused on bottle F, following a storage duration of 72 hours. The results derived from the iodine test showed no discernible alteration in color. This empirical data substantiated the assertion that the compound lacked elemental iodine when stored outside a refrigerated condition. This could be attributed to its volatilization, induced by elevated ambient temperatures, exposure to light, and sunlight.

Iodine Deficiency Disorders (IDDs) is a problem in Ghana. The research results showed that 54% of family heads aged 26 - 41 years with junior high school education had low knowledge about iodine salt and iodine deficiency disorders. This affects how to buy good salt in the market, how to store salt in the kitchen, and how to cook food using iodine salt for households in Ghana [82].

## 4. Conclusions and Recommendation

### 4.1. Conclusions

In conclusion, before the Dutch and Indonesian governments came to Papua, the ancestors of indigenous Papuans consumed halogen water to improve nutritional status, and immune system, prevent infectious diseases, prevent goiter, and increase children's growth and development. These compounds were beneficial for the ancestors of indigenous Papuans who lived far from the sea, as well as provided good offspring for forest animals and humans after consumption. The types of laboratory tests included physical/field, inorganic chemical, organic chemistry, disinfectant, and water microbiological examinations. Halogen water after processing was shown to be better compared to the pre-processed state.

The halogen water, whether stored in the refrigerator or not, was subjected to processing. The report findings showed that halogen water stored in the refrigerator contained iodine, while the non-refrigerated variants did not contain the element. Due to their inherent instability, these compounds required refrigeration to maintain quality, thereby emerging as vital elements for pregnant women, breastfeeding mothers, babies, and toddlers by contributing to the cognitive development of school-age children.

### 4.2. Recommendation

The processing of halogen compounds worldwide has not adequately addressed the nutritional needs of vulnerable groups, including women of childbearing age, pregnant and nursing mothers, infants and toddlers, as well as schoolchildren who require nutritious drinks to support cognitive development. However, it was essential that the processing and consumption of halogen compounds adhered to the Nutrition Adequacy Rate (NAR) recommended by the Food and Drug Management Center (FDMC). This ensured that consumers received health benefits without risking harm from excessive consumption.

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