Efficacy Test of Hypochlorous Acid from Thai Rock Salt

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Abstract

HOCl is an antiseptic solution for wounds produced from pure salt, with a concentrated free chlorine of 0.05%, pH 6-7 and ORP of 800-950 mV. Traditional Thai medicine uses salt to heal wounds and prevent rotting, giving rise to the idea of developing HOCl from Thai salt, sea salt, rock salt, and pink Himalayan salt to replace high-cost imported HOCl such as Envirolyte™, the purpose of which is to test the composition and physical properties of sea salt, Thai rock salt from 3 sources, and pink Himalayan rock salt from Pakistan compared to pure salt. Salt that has been tested for physical properties and contaminants is produced into Thai HOCl and tested for components. Physical Properties and Performance Compared to the standards of the Centers for Disease Control and Prevention (CDC) and the U.S. Environmental Protection Agency (EPA). Methods A review of the benefits of salt in Thai traditional medicine recipes. Sea salt, rock salt, pink Himalayan rock salt, refined salt, Faraday's Law of Electrolysis, HOCl, Envirolyte™. Results HOCl produced from Thai salt had an initial pH of 8.25 and an ORP of 1,100 mV. Efficacy tests showed that 100% concentration reduced germ content (Colony-forming unit (CFU) reduced pathogens up to 0 CFU log 6 in 3 minutes, 15 minutes, 30 minutes, and 60 minutes, concentration of 10% reduced pathogens up to 0 CFU log 6 in 3 minutes, 15 minutes, 30 minutes and 60 minutes, 10% concentration reduced pathogens up to 50 CFU log 5 in 3 minutes, 4 CFU log 5 in 15 minutes, 0 CFU log 5 in 30 minutes, and 0 CFU log 6 in 60 minutes. Thai HOCl was able to reduce the number of bacteria to an undetectable basis throughout the study period. In summary, each salt source has a different amount of sodium chloride and impurities. Rock salt from the South Salt Pond, Bo Klea District, Nan Province is of the best quality, suitable for the production of Thai HOCl, which has properties and efficacy similar to Envirolyte™ and meets CDC/EPA standards. Thai HOCl can be effectively used in

general sanitation, food sanitation, and food contact surfaces. Thai HOCl is highly effective against various pathogens at a more affordable price than foreign HOCl with the same standard.

Keywords: Acid oxidizing solution, Envirolyte, Hypochlorous acid, Medical equipment

Introduction

Sodium hypochlorite (NaOCl), a common chlorine compound, is widely used as a disinfectant and bleaching agent. While its 0.5% w/v solution (Dakin's solution) has served as an antiseptic for infected wounds and has a long history in the food industry, it poses risks. NaOCl cannot fully oxidize food constituents, leading to the formation of harmful byproducts like chloroform, halo acetic acids, and trihalomethanes, which are known carcinogens and mutagens (National Center for Biotechnology Information, 2025).

In contrast, Thai traditional medicine recognizes the preservative and wound-healing properties of local salts (Sangarun, 2014). This historical use inspired the idea to produce hypochlorous acid (HOCl) from readily available Thai sea salt, rock salt, or even pink Himalayan rock salt, as an alternative to expensive imported HOCl such as Envirolyte™. Beyond wound care, traditional texts attribute various health benefits to rock salt, including aiding digestion, expelling parasites, balancing bodily humors, dissolving gallstones, and nourishing the body's elements.

Thai traditional medicine often combines rock salt with other salts. For instance, "Alkali salt," a mixture of sea salt, rock salt, and ashes from burning snake grass, is used for intestinal cleansing and treating urination issues. Rock salt is also a key component of the "Five Salts Formula," limiting amount of salt, which consists of 5 types of salt in the same ratio: Rock Salt, Pic Salt, Vic Salt, Bubble Salt and Sea Salt, its properties, cure to treat various ailments like night fever, dropsy, and dysentery, while also nourishing lymph and cleansing the intestines.

Prior to medicinal use, Thai rock salt undergoes a purification process called "Satu," involving high-temperature roasting to eliminate moisture and sterilize it (Sangarun, 2014).

An effective alternative to traditional chlorine-based disinfectants is Electrolyzed Water (EW) or Electrolyzed Oxidizing Water (EOW). This solution is produced by electrolyzing a dilute sodium chloride (NaCl) solution in a chamber where anode and cathode are separated by a membrane. EOW exhibits potent antimicrobial properties, destroying bacteria and viruses by

electrically charging gram-negative hosts through direct contact, often via nebulization or cold steam sterilization.

EOW disinfectants include Acid Electrolyzed Water (AEW) and Neutral Electrolyzed Water (NEW). While AEW effectively reduces bacterial populations, its low pH, rapid loss of chlorine gas (Cl_2), and potential impact on sensory characteristics limit its broader use, particularly with food. NEW, however, offers strong antimicrobial activity within a neutral pH range (6.5-8.5). This neutrality makes it suitable for food applications as it doesn't alter food pH, color, or appearance, nor does it corrode equipment or irritate skin as severely as AEW. Despite these advantages, research specifically on NEW's effects on pathogens remains limited (Reisch , 2009).

Thai HOCl is produced by dissolving rock salt in clean water, followed by direct current electrolysis. This process separates the salt solution, forming dissolved chlorine and a weak acid. HOCl, the most active component in this chlorine solution, is 80-100 times more effective against bacteria than hypochlorite ion (OCl^-). A concentration of only 10-30 ppm of HOCl is sufficient for bactericidal action, with a 10 ppm HOCl solution being equivalent to 100 ppm NaOCl solution in its disinfectant effect (HOCl.com, 2025).

Extensive research confirms the production of HOCl from refined salt. However, there's a significant knowledge gap regarding the use of indigenous Thai salts for HOCl synthesis. Our research aims to fill this gap by evaluating various Thai salts for their suitability in HOCl production, and subsequently assessing the comparative efficacy and economic viability of such an application.

Objectives

1. Analyze Salt Composition: Determine the elemental composition of sea salt, three Thai rock salt sources, pink Himalayan rock salt, and commercial pure salt.

2. Synthesize Thai HOCl: Produce hypochlorous acid (HOCl) using Thai salt sources that meet specified physical property and contaminant criteria.

3. Characterize Thai HOCl: Evaluate the physical characteristics of the synthesized Thai HOCl.

4. Assess Microbicidal Efficacy: Determine the microbicidal efficacy of Thai HOCl against *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Enterococcus, Aspergillus Niger, Listeria monocytogenes, Legionella pneumophilia*, and *Salmonella typhimurium*. Efficacy will be defined as a bacterial reduction exceeding Log 5 (>99.999%), aligning with

EN 1040 and EN 1276 standards.

5. Compare Efficacy and Cost: Conduct a comparative analysis of the efficacy and production cost between Thai HOCl (from Thai salt) and imported HOCl products.

Methods

1. Literature reviews, Salt benefits in Thai traditional medicine, Sea Salt, Rock Salt, Pink Himalayan Rock Salt, Refined Salt, Faraday's Laws of Electrolysis, Hypochlorous Acid, Envirolyte™, Physical Properties, and Envirolyte™.

2. Quantitative suspension test standard

    a. EN 1040 test conditions and test requirements

    b. EN1276 test conditions and test requirements

3. Test Sample

    a. Sea Salt and Three Rock Salt from different location in Thailand, and Pink Himalayan Rock Salt from Pakistan. Test for compositions and impurity.

    b. Three HOCl samples from Rock Salt was made from set up HOCl generator and Test for physical properties.

4. Quality inspection

    a. Raw material compositions

5. HOCl price

Salt benefits in Thai traditional medicine

1. Colds.
2. Rhinitis, stuffy, runny nose, chronic rhinitis.
3. Dry throat and hoarseness.
4. Induce vomiting, eat poisonous food, drinking too much alcohol, indigestion, upset stomach.
5. Conjunctivitis, there is swelling, redness, and a lot of eye discharge.
6. Dental care.
7. Brain is not clear.
8. Swollen, itchy skin.

Salts

Table 1 shown type of salts and its properties, Sea salt, Rock salt, Pink Himalaya Rock salt, and Refined salt.

Table 1 Type of salts

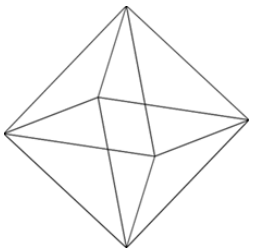
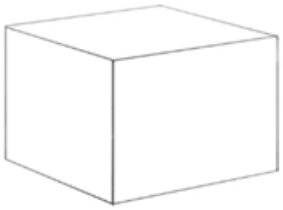
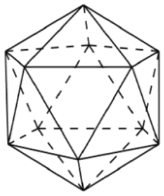
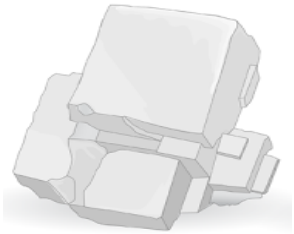
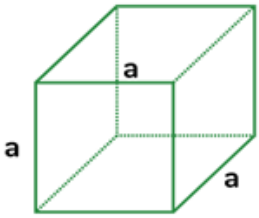
Salts	Physical characteristics
Sea salt	 Figure 1a. Sea salt crystals  Figure 1b. Sea salt structure (Source: Weird Science, 2021) Sea salt, also known as table salt or sodium chloride (NaCl), is a staple in cooking and food preservation. It typically contains iodine, which is crucial for preventing goiter and stunted growth, unlike rock salt which is iodine-free. Characterized by its salty taste, sea salt is a vital source of dietary sodium. It is harvested through the precipitation of seawater, forming distinctive white, pyramid-shaped crystals (Figures 1a, 1b) with a melting point of 800.7 °C.
Rock salt	 Figure 2a. Rock salt crystals  Figure 2b. Rock salt structure (Source : Rock salt crystals, 2024) Rock salt, primarily found in Thailand's northeastern regions (Chaiyaphum, Maha Sarakham, Yasothon, Ubon Ratchathani, and Udon Thani), is extracted from salt deposits or saline soil. Naturally, it boasts high purity sodium chloride (NaCl), making it ideal for industrial applications rather than direct culinary use due to its lack of iodine. To address this, potassium iodide is now commonly added to rock salt, transforming it into the familiar iodized salt suitable for cooking. Physically, rock salt forms cubic crystals (Figures 2a, 2b) and has a melting point of 800 °C.

Table 1 Type of salts (Continue)

Salts	Physical characteristics
Pink Himalaya Rock salt	  Figure 3a Pink Himalayan Rock salt crystals Figure 3b Pink Himalayan Rock salt structure (Source: Grains, 2025) Pink Himalayan rock salt crystals formed 250 million years ago from evaporated seawater under immense pressure, creating their distinctive pink structure (Figures 3a, 3b). This natural salt contains over 84 minerals, including calcium, magnesium, potassium, and iron.
Refined salt	  Figure 4a Refined salt crystals Figure 4b Refined salt structure (Source: Atoms In Motion, 2024) Refined salt, commonly known as table salt, undergoes chemical processing for whitening, purification, and preservation, and is typically fortified with iodine. Primarily composed of sodium chloride (NaCl), its crystals exhibit a cubic structure, specifically a face-centered cubic lattice. In this arrangement, sodium and chloride ions alternate in a repeating pattern, with each ion surrounded by six ions of the opposite charge, giving the crystals their characteristic cube-like appearance (Figures 4a and 4b).

Sea Salt, Rock Salt, and Refined Salt are different Table 2. Shown the differences between Refined Salt and other types of salt (TRS, 2025).

Table 2 The differences between Refined salt and other type of salts

Refined Salt	Sea Salt and Rock Salt
Modern production technologies from Europe	Local wisdoms
White and clean salt without adulterated things	Adulterated things, soil, pebbles, and sand from salt fields
Fine salt granules	Rough salt granules
Moistness not higher than 2%	High moistness of 8–10%
Whole-year production	Production period from January to April
Constant prices and controllable production costs	Volatile prices according to seasons
Standardized and constant iodine content because of low moistness and iodine spray controlled with computer systems	High moistness salt causing volatile iodine content
Environmentally friendly production	Soil collapse and adverse effects on communities and environments. Boiling salt from chaff can cause air pollutions

(Source: TRS, 2025)

Faraday's Laws of Electrolysis

In 1834, Michael Faraday, a physicist and chemist, invented a process for splitting water using electricity, Electrolysis, for the first time set up two laws called Faraday's Laws of Electrolysis, which are the main basis of electrochemistry until today.

Electrolysis of water separation process is the process of passing electric current directly into a solution that has electrical properties, water with pure salt, NaCl, causes a chemical reaction, oxidation to get new compounds, including HOCl, OCl^-, NaOCl, OH^-, H_2O_2.

Hypochlorous Acid

Hypochlorous Acid (HOCl), also known as Electrolyzed Water (EW) or Electrolyzed Oxidizing Water (EOW), is a weak, unstable acid found only in solution. This electron-accepting molecule plays a crucial role in oxidation- reduction reactions. Naturally produced by

mammalian white blood cells, HOCl is safe for biological applications, posing no harm to skin or eyes and causing no burning sensation.

HOCl is synthetically produced by dissolving refined salt (typically 99.9% NaCl with minimal impurities like 0.15% moisture and 10 ppm potassium ferrocyanide) in clean water, followed by electrolysis. During this process, NaCl dissociates into negatively charged chloride ions (Cl^-) and positively charged sodium ions (Na^+). Concurrently, water breaks down into hydroxide ions (OH^-) and hydrogen ions (H^+).

At the anode, Cl^- and OH^- ions transfer electrons, leading to the formation of oxygen gas, chlorine gas, hypochlorite ion (OCl^-), hypochlorous acid (HOCl), and hydrochloric acid (HCl). Conversely, H^+ and Na^+ ions migrate to the cathode to receive electrons, producing hydrogen gas and sodium hydroxide (NaOH).

Disinfectant solutions derived from this process include Acidic Electrolyzed Water (AEW) and Neutral Electrolyzed Water (NEW). While AEW effectively reduces bacteria, its low pH, rapid volatilization of dissolved chlorine gas (Cl_2), and potential impact on pathogens limit its widespread use. In contrast, NEW exhibits strong antimicrobial activity with a neutral pH (6.5-8.5). This neutrality makes it suitable for food applications as it preserves food pH, color, and appearance, and causes less corrosion to equipment or irritation to hands compared to AEW.

Water at the

Anode is called Strong Acidic Water with a pH < 2.7 ORP ≥ +800 to +1000 mV.

Cathode is called Strong KANGEN Water with a pH > 11 ORP -800 to -900 mV.

The chemical composition and physical properties of HOCl, along with its disinfection, antimicrobial, and sanitizing efficacy, are influenced by factors such as brine concentration, electrical energy, reaction time, electrolysis conditions, temperature, and pH (Aniyyah et al., 2021).

HOCl effectively eliminates viruses, bacteria, fungi, and fungal spores by destroying microbial cell walls and inhibiting growth. It is 80-120 times more potent than chlorine bleach in killing germs. With over 30 years of established use and ongoing research, HOCl is widely applied for disinfection in food processing, poultry farms, water treatment, and healthcare settings including wound care, dentistry, and medical equipment sterilization. Sanitization, in this context, refers to reducing germ levels to a safe extent without compromising product quality or safety (Pfuntner, 2011).

HOCl was initially developed in Russia in 2008 by Hricova et al. for water decontamination and hospital disinfection. By the 1980s, its use expanded to Japan, first for sterilizing medical equipment. Concerns over foodborne pathogens in the late 1990s led to its adoption in food safety, where it proved highly effective and more cost-efficient than chlorinated water.

Different concentrations of HOCl are suitable for various applications:

200-400 PPM: Ideal for cleaning floors, surfaces, bathroom mold, tables, and curtains, as well as for deodorizing and trapping airborne dust and germs.

50-100 PPM: Safe for use as a skin disinfectant spray, mask cleaning (without damaging polymer surfaces), and sanitizing children's toys, kitchen utensils, and sinks.

HOCl is a weak acid that partially dissociates into hydrogen and hypochlorite ions (as shown in Equation 1) within a pH range of 6.5 to 8.5.

$$HOCl \leftrightarrow H^+ + OCl^- \quad (1)$$

HOCl's germicidal effectiveness is significantly higher than that of OCl^-. Its dissociation is pH-dependent: below pH 6.5, HOCl remains undissociated, while above pH 8.5, it fully dissociates into OCl^-. Table 3 illustrates how pH influences the distribution of chlorine between HOCl and OCl^-.

Table 3 HOCl and OCl^- % is determined by pH

Disinfection	pH	% OCl^-	% HOCl
	4	0	100
Hypochlorous Acid	5	0	100
	6	1.8	98.2
	7	16.7	83.3
	8	67.8	32.2
	9	95.5	4.5
	10	99.5	0.5
Bleach	11	99.95	0.05

(Source: hocl.com, 2025)

Envirolyte™ Physical Properties

Table 4. shown Chemical Composition of Envirolyte™ and its Function.

Table 4 Chemical Composition of Envirolyte™ and its Function

Component	Synonym	CAS No.	W/V %	Function
Sodium Chloride	Salt, Sea Salt, NaCl	7647-14-5	0.0015	Natural salt is the source of sodium and chlorine. Their Compounds, hydrochloric acid, chlorates, sodium carbonate, hydroxide, etc.
Water	Deionized Water, H_2O	7732-18-5	99.8	Dissolve Sodium chloride and other substances.

(Source: Envirolyte™, MSDS, 2017)

Envirolyte™ composition

Envirolyte™ contains active chlorine compounds, HOCl 0.01-0.5 %W/V generated from NaCl by electrolysis. The solution contains no compounds as per the regulations for toxic compounds (67/548/EWG) as shown in Table 5.

Table 5 Envirolyte™ composition

Ingredients	Symbol	% w/v	CAS No.	EINICS No.
Sodium Chloride	NaCl	0.26	7647-14-5	231-598-3
Hypochlorite ion	OCl^-	0.0005		14380-61-1
Hypochlorous acid	HOCl	0.05	7790-92-3	232-232-5
Water	H_2O	99.69	7732-18-5	231-791-2
ORP	mV	970		
The acidity and alkalinity at 25°C	pH	5.5	APHA 2005 (4500-H+B)	

(Source: Envirolyte™, 2017)

Materials and Methods

Thai HOCl

Thai HOCl is produced through the electrolysis of a sodium chloride solution, where positive and negative electrodes drive an electrochemical reaction. This process generates ions, specifically OH^- and Cl^- (College side kick, 2025).

Upon completion of the reaction, Thai Rock Salt HOCl exhibits the composition detailed in Table 6 and maintains an Oxidation-Reduction Potential (ORP) between 950-1100 mV. This solution effectively destroys bacteria and viruses by electrically charging gram-negative hosts through direct contact, typically via nebulizers or cold steam sterilization.

Table 6 Composition of Thai HOCl

Components	Formula	Percentage %
Sodium hypochlorite	NaOCl	0.03500
Chlorine dioxide	ClO_2	0.00110
Sodium chlorate	$NaClO_3$	0.00150
Ozone	O^3	0.00002
Total oxidants		0.03762
Water	H_2O	99.96238

(Source: Author, 2025)

Table 7 outlines the chemical composition and functional roles of Thai Rock Salt HOCl. It contains 0.0014844% W/V Sodium Chloride (NaCl), sourced from natural salt. This NaCl provides chlorine and sodium, along with their compounds such as hydrochloric acid, chlorates, sodium carbonate, and hydroxide, which act as electrolytes, buffers, and matrix modifiers. The remaining 99.8% W/V is de-ionized water (H_2O), serving as the primary solvent, dispersing medium, hydrating agent, and promoter of chemical changes.

Table 7 Thai Rock Salt HOCl composition and information ingredients

Component	Synonym	CAS No.	% W/V	Function
Sodium Chloride	Salt, Sea Salt, NaCl	7647-14-5	0.0014844	Natural salt is the source of chlorine and sodium as well as of all, or practically all, their compounds e.g., hydrochloric acid, chlorates, sodium carbonate, hydroxide, etc. Used as an electrolyte, buffers, matrix modification.
Water	Water, H_2O, Deionized Water	7732-18-5	99.8	It allows substances to dissolve and functional as a solvent, dispersing medium, hydrate, and promoter of chemical changes.

(Source: Author, 2025)

Thai Rock Salt HOCl caused by the separation of substances with positive and negative electrodes, when passing through the saline water down to causing electrolyte reactions of the Sodium Chloride solution is an ion-containing compound which is OH^- and Cl^- as the equation. (College side kick, 2025).

$$NaCl + H_2O \rightarrow Na^+ + Cl^- + H^+ + OH^- \quad (1)$$

$$2Cl^- \rightarrow Cl_2 + 2e^- \quad (2)$$

Anode: $$Cl_2 + H_2O \rightarrow HOCl + HCl \quad (3)$$

Cathode: $$2Na^+ + 2H_2O \rightarrow 2NaOH + H_2 \quad (4)$$

Hypochlorous Price

In Thailand, the pricing of HOCl products that meet the European disinfectant standards EN 1040 and EN 1276, as shown in Table 8, varies by brand.

Table 8 The prices of HOCl products in Thailand

Brand	Size (mL)	Price (THB)
SteriPlant™	1,000	1,600.00
Envirolyte™	1,000	750.00
Clean-U	1,000	1,800.00
Thai HOCl	1,000	350.00

(Source: Author, 2025)

Test samples

1. Salt samples

From Table 9 and Figure 5. Salt samples from Udon Thani, Sakon Nakhon, and Nan province, Pakistan and Sea salt from Samut Sakhon was send to SGS, Bangkok, Thailand on February 6th, 2024.

Table 9 Salt samples

No.	Salts	Location
1.	Ban Phue rock Salt	Non-Thong Subdistrict, Ban Phue District, Udon Thani
2.	Krator rock salt	Wanonnivas Subdistrict, Wanonnivas District, Sakon Nakhon
3.	Mountain rock salt	Bo Klea Tai Subdistrict, Bo Klea District, Nan
4.	Himalayan rock salt	Himalayas, Pakistan
5.	Sea salt	Na Khok Subdistrict, Mueang District, Samut Sakhon

(Source: Author, 2025)

Figure 5 Salt sample send to test, February 6, 2024

(Source: Author, 2025)

2. HOCl samples

Figure 6 and Table 10 shown HOCl test samples was made from Ban Phue Rock Salt, Krator rock salt, Mountain rock salt and send to test compositions and properties.

Table 10 HOCl test samples

No	HOCl from
1.	Ban Phue Rock Salt
2.	Kartar Rock Salt
3.	Mountain Rock Salt

(Source: Author, 2025)

Figure 6 HOCl test samples send to test

(Source: Author, 2025)

Quality inspection

1. Raw material compositions

The standard salt composition as shown on Table 11. Normally Refined salt 99.9% was use for Envirolyte™.

Table 11 Standard salt composition

Parameters	Formula	Units	Analysis Method
Sodium Chloride	NaCl	%	Dry basis by difference
Moisture	H_2O	%	Oven dry
Insoluble matter	IM	%	Gravimetric
Calcium	Ca	ppm	Titration
Magnesium	Mg	ppm	Titration
Iron	Fe	ppm	Spectrophotometry
Sulphate	SO_4	%	Titration
Potassium ferrocyanide	$K_4Fe(CN)_6$	ppm	Spectrophotometry

(Source: Author, 2025)

Salt composition tested results

Table 12 details the comparative composition of various salt sources. Refined salt, alongside rock salts from Ban Phue, Krator, and Mountain, consistently showed the highest NaCl content, reaching 99.77%. In contrast, sea salt contained less NaCl (98.00%) and notably higher moisture (0.95%). Significantly, both sea salt and Himalayan rock salt presented elevated levels of impurities and potentially toxic substances, along with higher iodine content (Figures 7, 8, 9). Therefore, sea salt and Himalayan rock salt are deemed unsuitable for HOCl production. Refined salt and the rock salts from Ban Phue, Krator, and Mountain emerge as the appropriate raw materials for HOCl generators.

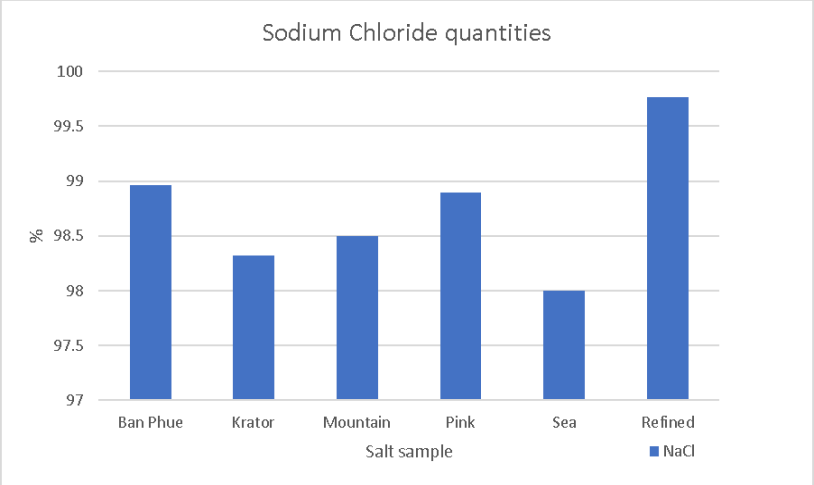


Figure 7 Sodium chloride quantities for each salt

(Source: Author, 2025)

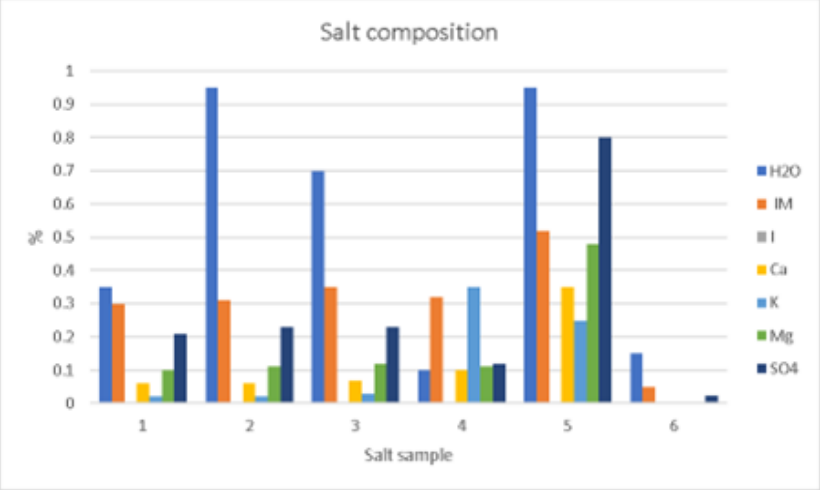


Figure 8 H_2O, Insoluble matter, I, Ca, K, Mg, SO_4 quantities for each salt

(Source: Author, 2025)

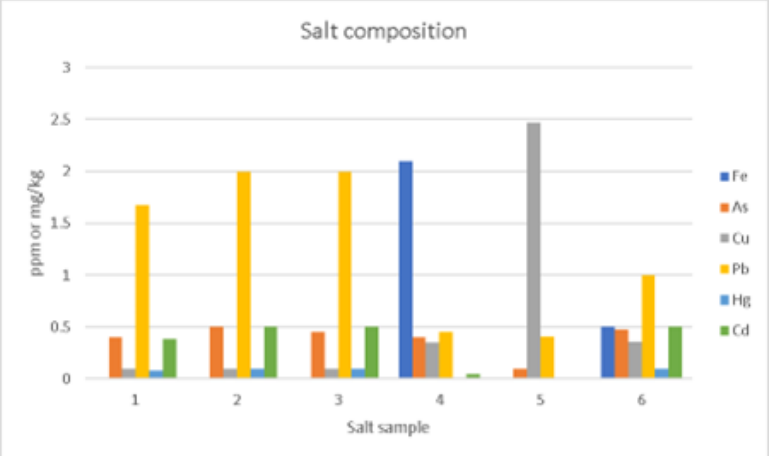


Figure 9 Fe, As, Cu, Pb, Hg, Cd quantities for each salt

(Source: Author, 2025)

Table 12 Salt composition tested results

Physical properties				Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
				Ban Phue	Krator	Mountain	Himalayan	Sea Salt	Refined
Odor				Odorless	Odorless	Odorless	Odorless	Odorless	Odorless
Taste				Salty taste No foreign taste	Salty taste No foreign taste	Salty taste No foreign taste	Salty taste No foreign taste	Salty taste No foreign taste	Salty taste No foreign taste
Color				White	White	White	Pink	Light grey	White
Grade				Food	Food	Food	Food	Food	Food
Size			mm	0.5-1.1	0.45-2.3	0.5-1.0	2-5	4-6	0.15-0.85
Sodium Chloride		NaCl	%	98.96	98.32	98.50	98.90	98.00	99.77
Moisture		H_2O		0.35	0.95	0.70	0.10	0.95	0.15
Insoluble matter		IM		0.30	0.31	0.35	0.32	0.37	0.05
Iodine		I					0.0005	0.0020	
Calcium		Ca		0.06	0.06	0.07	0.10	0.12	0.00015
Potassium		K		0.02	0.02	0.03	0.35	0.10	0.00010
Magnesium		Mg	%	0.10	0.11	0.12	0.11	0.21	0.00001
Sulphate		SO_4		0.21	0.23	0.23	0.12	0.25	0.02500
Iron		Fe	ppm				2.10		0.50
Copper		Cu		0.10	0.10	0.10	0.35	2.47	0.36
Arsenic	**Max 0.5**	As		0.40	0.50	0.45	0.40	0.10	0.48
Lead	**Max 2.0**	Pb		1.68	2.00	2.00	0.45	0.41	1.00
Mercury	**Max 0.1**	Hg		0.08	0.10	0.10	0.01	0.01	0.10
Cadmium	**Max 0.5**	Cd		0.38	0.50	0.50	0.05	0.01	0.50

Remarks: Ministry of Public Health Announcement, (Issue 414) 2020, Issued in accordance with the Food Act B.E. 2522, Subject: Standards for food that contains contaminants

(Source: Author, 2025)

Table 13 presents a comparison of HOCl properties derived from various salt sources against Envirolyte™. HOCl produced from Rock Salt 1 exhibited a higher concentration of key substances, closely mirroring Envirolyte™'s profile. In contrast, sea salt yielded poor results, producing HOCl with significantly lower substance levels than rock salt. Himalayan rock salt also resulted in lower substance concentrations compared to Envirolyte™. Among the rock salt varieties, Rock Salt 1 stands out as the most suitable material for HOCl production in Thailand.

Table 13 Physical properties tested results of HOCl from each salt

Physical properties	Formula	RockSalt1	RockSalt2	RockSalt3	Envirolyte™
Clean water	H_2O	99.6915	99.6964	99.6924	99.6900
Sodium Chloride	NaCl	0.2579	0.2562	0.2567	0.2595
Hypochlorous acid	HOCl	0.0496	0.0493	0.0494	0.0500
Hypochlorite ion	OCl^-	0.0010	0.0019	0.0015	0.0005
ORP	mV	950	895	935	970
Acidity and alkalinity at 25°C	pH	5.6	5.9	5.7	5.5

(Source: Author, 2025)

2. Quantitative suspension test standard

2.1. EN 1040 Test conditions and test requirements

EN 1040 evaluates the basic bactericidal activity of chemical disinfectants and antiseptics under standard conditions as shown in Figure 10. (Microbe investigations, EN 1040, 2025).

Mandatory test microorganisms

- *Pseudomonas aeruginosa* (ATCC 15442)
- *Staphylococcus aureus* (ATCC 6538P)

Additional strains

- *Escherichia coli* (ATTC 8739)
- *Enterococcus hire* (ATTC 10541)
- *Klebsiella pneumoniae* (ATCC 4352)
- *Methicillin-resistant Staphylococcus aureus* (ATCC 33591)
- *Salmonella enterica* (ATCC 10708)
- *Candida Albicans* (ATCC 3017)

Test temperature 20 °C

Contact time 5 min

Log reduction Tested product must achieve 5 log reduction value to pass EN 1040 test

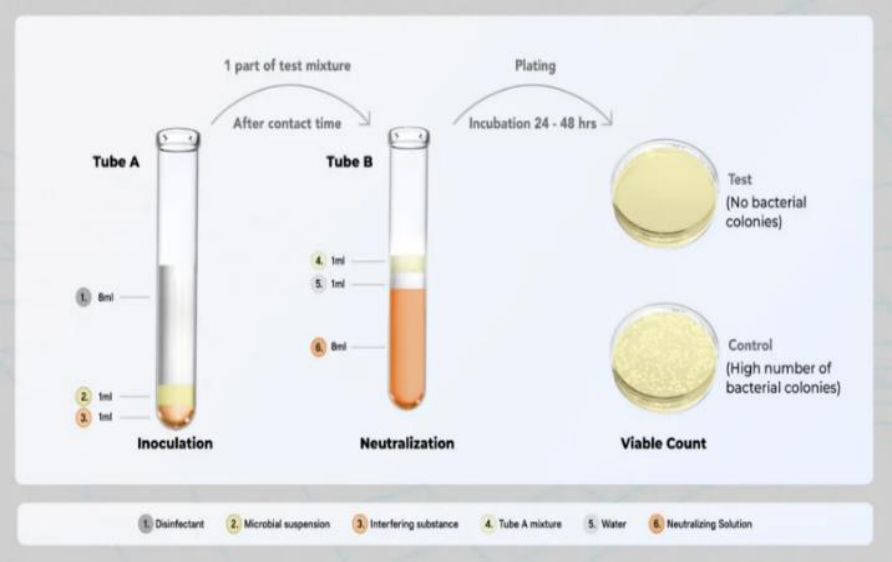


Figure 10 BS EN 1040: 2019 Test

(Source: Microbe investigations, 2025)

2.2. EN1276 test conditions

The test conditions specified by the standard are designed to closely simulate practical use conditions to ensure reliability in results as shown in Figure 11. (Microbe investigations, 2025).

Test organisms

The bactericidal activity of the product is tested using the following strains as shown in Table 14.

Table 14 Inoculum concentration

Inoculum	Method	CFU/mL
Candida albicans	DSM 1386	8.1×10^8
Staphylococcus aureus	ATTC 6538	9.3×10^8
Pseudomonas aeruginosa	ATTC 15442	4.2×10^8
E. coli	ATTC 10536	4.2×10^9
Enterococcus hirae	ATTC 10541	1.0×10^{10}
Asp. Niger	C 1103 (Oxoid)	4.0×10^6
Listeria monocytoses	(Oxoid)	3.0×10^9
Legionella pneumophilia	C 3950 (Oxoid)	6.0×10^3
Salmonella typhimurium	C 6000 (Oxoid)	8.0×10^3

(Source: Author, 2025)

Contact time

The contact time ranges from 1 minute to 60 minutes, depending upon product use and manufacturer's instructions.

Test Temperature

Test temperature 4-40 °C.

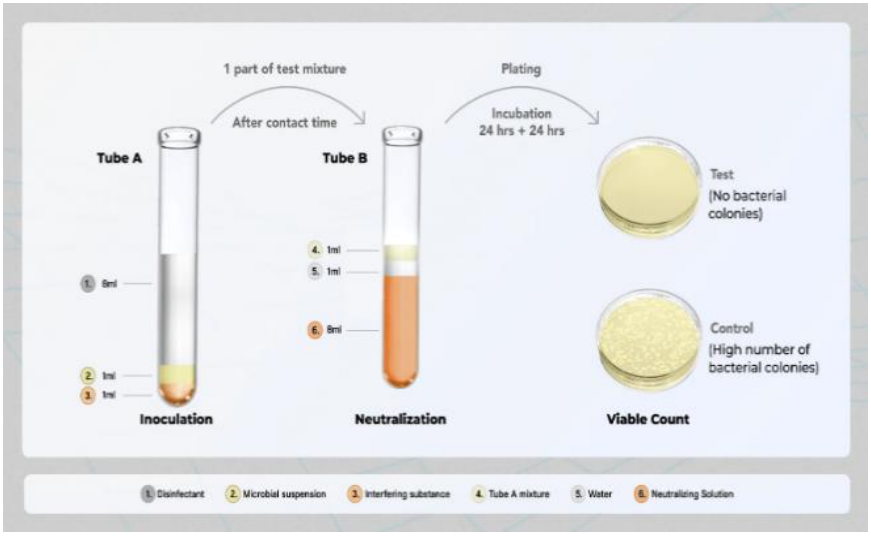


Figure 11 BS EN 1276: 2019 Test method

(Source: Microbe investigations, 2025)

Tests

The tests have been conducted in regulations to EN1276 and tested in the given standard time. Thai HOCl was stored in a refrigerator at 8 °C for 5 days. For thinning Thai HOCl we have used reversed osmosis water, a clear, colorless liquid.

A thinning neutralization procedure was conducted, a lower amount of 0.3 gm/l Cow albumin, sterilized and filtered using membrane filters, has been used. The tests were conducted for 3 days and evaluated after the incubation at 37 °C (or *Candida albicans* 30 °C for 2 days and evaluated.

Sodium Thiosulphate 0.5 % use as a neutralizer, which has been sterilized by filtration. As for the growth mediums the Bacteria TSA-Agar (Oxoid) and also Asp. Niger Sabouraud-Agar (Oxoid) was used.

The test procedure set up

1 mL solution was made up of 0.1 mL Inoculum. After 2 minutes.

8.9 mL Thai HOCl was added into the mixture. After

1 mL of the mixture was put into an 8 mL test tube and

1 mL sterilized water was added. After 5 minutes reaction time.

1 mL was taken out and put on the petri dish using a pipette, then

15 mL of cooled liquid growth medium was poured over the substance.

After the Agar solidified the plates were then hatched at the correct temperatures and then evaluated.

Bacterial effectiveness of Thai HOCl by EN 1276 phase 2 Level 1. Tests with lower albumin amount.

Thai HOCl is an electrolyte liquid which has bacteria disinfecting properties through a mixture of active chloride, ozone, hydrogen peroxide and other active substances. The initial pH 7.25 and ORP 1,100 mV.

The inoculum had concentrations, for a clearer understanding both test results the test has been done in two stages. The first tests have been done in October 14, 2024. The second stage was done in December 5, 2024.

Results

Thai HOCl efficacy test results

Thai HOCl efficacy test, 1st Stage bacteria count results, Colony-forming unit (CFU), (Revive, 2025), the initial population of live germ. From Table 15. showed that the treatment treated the number was taken from CFU, the original measurement found on the Inoculum. The number below is the logarithmic reduction factor as Shown in Table 16.

Table 15 1st Stage initial population of live germ

Bacteria's	CFU/mL	
Candida albicans	8.1	10^8
Pseudomonas aeruginosa	4.2	10^8
Staphylococcus aureus	9.3	10^8
E. coli A	4.2	10^9
Enterococcus	1.0	10^{10}

(Source: Author, 2025)

Table 16 1st Stage bacteria count results

Thai HOCl 100%	Candida	Ps. aeruginosa	Staph. aureus	E. Coli	Enterococcus
Minutes	CFU log 6	CFU log 6	CFU log 6	CFU log 6	CFU log 6
3	0	0	0	0	0
15	0	0	0	0	0
30	0	0	0	0	0
60	0	0	0	0	0
Thai HOCl 50%	Candida	Ps. aeruginosa	Staph. aureus	E. Coli	Enterococcus
Minutes	CFU log 6	CFU log 6	CFU log 6	CFU log 6	CFU log 6
3	0	0	0	0	0
15	0	0	0	0	0
30	0	0	0	0	0
60	0	0	0	0	0
Thai HOCl 10%	Candida	Ps. aeruginosa	Staph. aureus	E. Coli	Enterococcus
Minutes	CFU log 6	CFU log 6	CFU	CFU	CFU log 6
3	2	0	log 3 1070	log 5 48	0
15	0	0	log 4 680	log 5 4	0
30	0	0	log 5 31	log 5 0	0
60	0	0	log 6 0	log 6 0	0

(Source: Author, 2025)

Thai HOCl efficacy test, 2nd Stage bacteria count results, the initial population of live germ was as shown in Table 17.

Table 17 2nd Stage initial population of live germ

Bacteria's	**CFU/mL**
Asp. Niger	4.0 10^6
Listeria monocytoses	3.0 10^9
Legionella pneumophilia	6.0 10^3
Salmonella typhimurium	8.0 10^3

(Source: Author, 2025)

From Table 18. Showed the treatment treated the number was taken from CFU, the original measurement found on the Inoculum. The number below is the logarithmic reduction factor. Thai HOCl had to reduce the live germ number by log 3 to pass EN 1276 requirements.

With Thai HOCl concentration 100% has passed the EN 1276 after an effect time of 3 minutes

With Thai HOCl concentration 50% has passed the EN 1276 after an effect time of 15 minutes

With Thai HOCl concentration 10% has passed the EN 1276 after an effect time of 30 minutes with exception to *Salmonella typhimurium*.

Table 18 2nd Stage bacteria count test results

Thai HOCl 100%	*Asp. Niger*	*List. Monocytogenes*	*Legionella*	*Salmonella*
Minutes	CFU log 6	CFU log 9	CFU log 3	CFU log 8
0	0	0	0	0
3	0	0	0	0
15	0	0	0	0
30	0	0	0	0
Thai HOCl 50%	*Asp. Niger*	*List. Monocytogenes*	*Legionella*	*Salmonella*
Minutes	CFU log 6	CFU log 9	CFU log 3	CFU log 8
3	0	Growth	0	Growth
15	0	0	0	0
30	0	0	0	0
Thai HOCl 10%	*Asp. Niger*	*List. Monocytogenes*	*Legionella*	*Salmonella*
Minutes	CFU log 6	CFU log 9	CFU log 3	CFU log 8
3	Growth	Growth	0	Growth
15	Growth	0	0	Growth
30	0	0	0	Growth

(Source: Author, 2025)

Test from 3rd party

Table 19 3rd party test results

Test Items	Method	Results	Units
Staphylococcus aureus	Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 23rd Edition, 2017, Part 9213 B and FDA BAM Online, 2016 (Chapter 12) -S. aureus	Less than 1	CFU/100mL
**Pseudomonas aeruginosa*	Based on Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 23rd Edition, 2017, Part 9213 E/API 20NE	Not detected	CFU/100mL
E. coli	Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 23rd Edition, 2017, Part 9221 F and FDA BAM Online, 2017 (Chapter 14) - E. coli	Not detected	CFU/100mL
**Listeria ssp.*	Based on FDA BAM Online, 2017 (Chapter 10)	Not detected	CFU/100mL
**Sodium Chloride*	Based on APHA, 23rd Edition, 2017	2411	mg/L

Test(s) Marked * On this report are not included in the BLQS DMSc Accreditation Scope.

From Table 19. Shown 3rd party test results, *Staphylococcus aureus* less than 1 CFU/100mL, *Pseudomonas aeruginosa* not detected, *E. coli* not detected, *Listeria ssp.* Not detected, in standard.

Discussions

The purity of salt used in hypochlorous acid (HOCl) production is critical, as contaminants can impact the final product's efficacy and stability. This study investigates various salt sources, comparing their compositions and the resulting HOCl properties to identify the most suitable option for HOCl generation.

A literature review and tested reports reveal significant variations in the sodium chloride (NaCl) content and impurity profiles of different salt types:

Refined Salt (Rock Salt Type): Often used in foreign HOCl production, refined salt typically boasts a high NaCl content of 99.77% and a low moisture content of 0.15%.

Sea Salt: Demonstrates a high impurity level, with iodine at 0.0020% and copper at 2.47 ppm.

Pink Himalayan Rock Salt (Pakistan): Contains elevated levels of iron (2.10 ppm), copper (0.35 ppm), and iodine (0.0050%).

Rock Salt Samples (Local Sourcing):

Rock Salt 1: NaCl 98.96%, moisture 0.35%

Rock Salt 2: NaCl 98.32%, moisture 0.95%

Rock Salt 3: NaCl 98.50%, moisture 0.70%

Based on these compositional and impurity analyses, Rock Salt 1, Rock Salt 2, and Rock Salt 3 were selected for further evaluation in HOCl production due to their relatively high NaCl content and manageable impurity levels compared to sea salt and Himalayan rock salt.

Physical Properties of HOCl Produced from Different Salt Sources

The selected rock salt samples were utilized to produce HOCl, and the physical properties of the resulting solutions were tested and compared against a commercial benchmark, Envirolyte™ as shown in Table 20.

Table 20 Physical Properties of HOCl Produced from Different Salt Sources

Salt Source	H_2O (%)	NaCl (%)	HOCl (%)	OCl^- (%)	ORP (mV)	pH
RockSalt1	99.6915	0.2579	0.0496	0.0010	950	5.6
RockSalt2	99.6964	0.2562	0.0493	0.0019	895	5.9
RockSalt3	99.6924	0.2567	0.0494	0.0015	935	5.7
Envirolyte™	99.6900	0.2595	0.0500	0.0005	970	5.5

(Source: Author, 2025)

Identifying the Optimal Salt Source

While Refined Salt (0.295% NaCl in HOCl solution) exhibits a slightly higher NaCl content in the final HOCl solution compared to RockSalt1 (0.2579%), Rock Salt 1 demonstrates comparable HOCl production efficiency and overall solution properties. Given its readily available nature and favorable characteristics, Rock Salt 1 is a suitable alternative to Refined Salt for the effective production of HOCl. Further investigation into the long-term stability and specific applications of HOCl derived from these various rock salt sources could provide additional insights.

Conclusion and Suggestions

Conclusion

Thai HOCl produced from Mountain Rock Salt (Bo Klea Tai, Bo Klea District, Nan) showed promising results, with its composition and properties closely matching those of Envirolyte™, an imported HOCl made from refined salt. This indicates that Thailand can utilize its own resources to develop HOCl with physical properties comparable to foreign products. This local production capability offers the potential for more affordable and effective disinfection medical equipment, fostering technological independence.

Thai HOCl significantly inactivated *Staphylococcus aureus, Pseudomonas aeruginosa, E. coli, Enterococcus, Asp. Niger, Listeria monocytoses, Legionella pneumophilia,* and *Salmonella typhimurium.*

Thai HOCl concentration 100% has passed the EN 1040 after an effect time of 3 min.

Thai HOCl concentration 50% has passed the EN 1040 after an effect time of 3 min.

Thai HOCl concentration 10% has passed the EN 1040 after an effect time of 60 min.

Thai HOCl concentration 100% has passed the EN 1276 after an effect time of 3 min.

Thai HOCl concentration 50% has passed the EN 1276 after an effect time of 15 min.

Thai HOCl concentration 10% has passed the EN 1276 after an effect time of 30 min.

with exception to *Salmonella typhimurium*.

The varying NaCl content and contaminants across different salt sources likely influence the properties of the resulting HOCl, impacting both its key components and disinfection efficacy.

The pricing of HOCl products that meet the European disinfectant standards EN 1040 and EN 1276, as shown in Table 9, varies by brand with the same size, 1,000 mL, SteriPlant™ 1,600.00 THB, Envirolyte™ 750.00 THB, Clean-U™ 1,800.00 THB, Thai HOCl 350 THB.

Crucially, Thai HOCl demonstrates promising results, with its essential composition and performance closely aligning with established international standards.

This makes Thai HOCl suitable for broad applications in general sanitation, including food sanitation and the disinfection of food-contact surfaces. Thai rock salt HOCl, in particular, proves highly effective against various germs with affordable price.

Suggestions

Food, medical, water and environmental agencies are depending more and more on NEW and EW as a basic chemical free sanitizer to protect the environment where food is prepared and providing sterile conditions for medical uses and water bio-safety.

HOCl is being used in industries that depended heavily on conventional sanitizers which were mainly chemical based. Although electrolysis was a well-known format of treating water for producing different types of by-products, the main applications today focused on sanitization and its efficacies.

As a safe non-toxic sanitizer, Thai HOCl sanitizing water shall be a common sight in private clinics, schools, hospitals, educational institutions and commercial uses such as food processing and packaging companies plus supermarkets with large cold storage and display facilities.

Application of Thai rock salt to produce and replace imports of general sanitation, food sanitation, and surface sanitation for disinfection. This makes it easy for the public and public health agencies to access with affordable price.

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