SSRG International Journal of Chemical Engineering Research
ISSN: 2394 – 5370 / https://doi.org/10.14445/23945370/IJCER-V11I3P101

Volume 11 Issue 3, 1-18, Sep-Dec 2024

Original Article

Evaluation of Health Hazards, Physicochemical Properties and Detection of Trace Elements in Frequently Utilized Body Soaps Purchased from Chattogram Local Market, Bangladesh

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Received: 02 September 2024 Revised: 19 October 2023 Accepted: 03 November 2024 Published: 20 November 2024

Abstract *- The use of beauty soap is a typical daily activity and is extremely popular in Bangladesh. The current study concentrates on evaluating various physicochemical features such as moisture content, pH, total alkali content, total fatty matter and some dangerous heavy metals such as Lead (Pb), Cadmium (Cd), Chromium (Cr) and Mercury (Hg) contamination in some beauty soaps regularly used by Bangladeshi people. The most crucial qualities describing the quality of soap are total alkali, fatty matter, pH, and moisture concentrations; these are always indicated in business transactions. Most of the studied samples' physicochemical properties fell within the recommended standard ranges by the International Standard Organization. However, in a few samples, pH, total alkali, and free alkali were found to be greater than the recommended values. The findings show that Fe, Zn, Mn, and Cr concentrations are within acceptable limits, whereas Pb, Ni, and Cd concentrations are determined to be below WHO/EU acceptable limits. However, the WHO found that the Chromium levels in Kumarika and Himalaya soaps were higher than allowed. The Hazard Quotient (HQ) and Chronic Daily Intake (CDI) associated with these metal intakes through dermal exposure are used to assess the potential health hazards. According to the estimated chromium Carcinogenic Risk (CR), it falls within the tolerable limit. The findings of cancer and non-cancer risk tests show that although there was little likelihood that using these soaps would increase one's risk of developing cancer or a non-cancer, the accumulation of trace metals over time and with continued use could be harmful to Bangladeshi citizens. So, precautions are necessary. One should not use one type of soap for a longer period.*

Keywords *- Beauty soaps, Chronic daily intake, Hazard quotient, Health risk, Heavy metals, Physicochemical properties.*

1. Introduction

The largest organ in the body, the skin, serves as a physical barrier to keep out numerous airborne contaminants. The chemicals in cosmetics, shampoos, and soaps come into direct touch with the skin when they are applied to it. [1] The major uses of toiletries are personal hygiene and body cleaning. These goods' high demand and quick consumption classify them as Fast-Moving Consumer Goods (FMCG). Both liquid and solid bath soaps are included in this category. Beauty soap is a specialized type of soap that is designed to enhance the skin's countenance and promote a healthy, radiant complexion. Beauty soaps are available in a wide range of formulations to cater to different skin types and concerns. There are variants suitable for dry, oily, sensitive, and combination skin, each offering specific benefits tailored to the skin's unique needs. Some beauty soaps also incorporate anti-aging properties, helping to minimize the appearance of fine lines and wrinkles. It is important to choose a beauty soap that suits your skin type and preferences, as well as ensure that it is dermatologic ally tested and free from harsh chemicals or irritants. [2] Consumer demand for natural cosmetic components is expanding because of the product's increased health and organic and ecological benefits. [3] More and more customers are turning away from synthetic chemicals found in cosmetics and beauty goods. The negative impacts of synthetic surfactants, the sustainability of the environment, and the friendliness of the large-scale commercial soap manufacturing in the plant are being highlighted. A natural soap is made by adding a functional ingredient made of a natural substance, like plant extract or essential oil, in place of a non-natural surfactant. The soap smells excellent for a long time, is less irritating, and has good detergency or cleaning power. Herbal soap, as the name suggests, is a type of soap that is made primarily from natural botanical ingredients. Herbal soaps are formulated to be free from synthetic additives, fragrances, and harsh chemicals, making them a popular choice for those seeking natural. The use of herbal soap can provide numerous advantages for the skin. It helps cleanse the skin without stripping away its natural oils, leaving it feeling nourished and hydrated. Additionally, herbal soaps are often biodegradable and environmentally friendly, making them a sustainable choice for conscious consumers. When choosing an herbal soap, it is essential to look for products that are made from high-quality natural ingredients and are free from synthetic additives or preservatives. This ensures that you can enjoy the full benefits of the herbs while minimizing the risk of skin irritation or adverse reactions. [4]

1.1. Chemistry of Soap

The type of oil used, the degree of saponification, the age of the soap, and the strength and purity of the alkali all affect the chemical properties of soap. [5] These chemical properties include pH, total free alkali, moisture content, and Total Fatty Acids (TFM). [6] For personal hygiene, home cleaning, and industrial purposes, soap is a multipurpose cleaning agent that is frequently used. Soap is a cleaning substance that combines fat, lye, and water. Lye is a general term for a few hydroxide substances. Sodium hydroxide (NaOH) creates bar soap, and potassium hydroxide (KOH) creates liquid soap.

1.1.1. Saponification Reaction

The process of making soap via chemical means is known as saponification. Triglycerides (fats or oils) are combined with a potent base, like sodium hydroxide or potassium hydroxide, to form soap molecules and glycerol as a byproduct of the reaction. However, the exact chemistry can vary based on the specific fats or oils used, the type of base used, and the production process. Additionally, there are various types of soaps, including syndet bars, liquid soaps, and speciality soaps, each with its own formulations and properties.

1.2. Total Alkali Content

Previously, the alkali used to make soap was derived from plant ashes. However, they are now produced by NaOH (sodium hydroxide) and KOH (potassium hydroxide), which are the alkali used in the production of soap. The most popular toilet soaps are sodium carboxylates. Hard soaps are produced from mixtures of solid fats that contain a larger proportion of sodium or potassium salts of higher fatty acids (palmitic acid, stearic acid).7 "An investigation of free alkali determinations in soap", Chicago, pp.8-9, 1936). The vegetable oils produce mixes with a higher percentage of oleic acid and linoleic acid, as well as soft soaps. [8] The ISO specification states that soaps should only contain less than 2% alkali content; however, the Bureau of Indian Standards (BIS) stipulates that acceptable grade soaps must have fewer than 5% alkali content. [9]

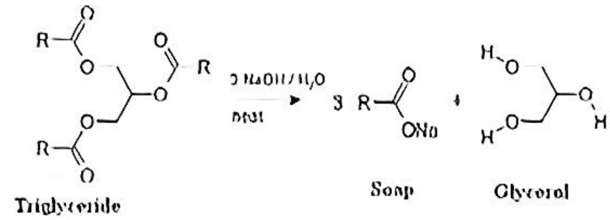

Fig. 1 Reaction of Soap

1.3. Total Fatty Matter

One of the most significant factors determining the quality of soap is the Total Fatty Matter (TFM), which is always indicated in business transactions. It is described as the total quantity of fatty matter, primarily fatty acids, that may be extracted from a sample after being split with a mineral acid, often HCl. Here, we applied this approach and notion to calculate the total fatty content of soaps. The total fatty matter is used to rank soaps. TFM is typically connected to soaps that are harder and of lower grade and that are made up of actual soap molecules derived from fats or oils. TFM is an essential factor in determining the effectiveness and mildness of soap for various applications, such as personal hygiene or cleaning.[10] In the context of soap production, TFM is a measure of the amount of saponified (converted into soap) fatty acids present in the soap formulation.

A higher TFM generally indicates a more pure and mild soap, as it contains a greater proportion of soap molecules and fewer residual impurities. Soaps with higher TFMs tend to be less harsh on the skin and offer better cleansing properties. TFM is a metric used to determine how much fatty matter is contained in soap. 'Normal', 'baby', 'transparent', and 'antibacterial' soaps are the several categories that the Bureau of Indian Standards (BIS) has assigned to bath or toilet soaps. Based on the overall amount of fatty content present in them, BIS divided toilet soaps into three groups. Grade I, or having good quality, is achieved if TFM is more than 76%. TFM over 60% falls under grade II, whereas TFM over 50% falls under grade III. Good soaps must have TFM above 76% in accordance with International Standards (ISO) [5].

1.4. pH of Soap

The pH range for healthy, normal skin is between 5.4 and 5.9, and the bacterial flora is normal. When using soap with a high pH, the skin's pH rises, which in turn increases the dehydrative effect, irritation, and changes in bacterial flora. The pH of most soaps on the market is not stated. Depending on the type of soap and its constituents, the soap's pH might change. Traditional soap is often created using the saponification process, which includes combining fats or oils with an alkali (such as sodium hydroxide or potassium hydroxide). This procedure is also known as bar soap or hard soap. A soap produced through the saponification process often has a pH level of 9 to 10, making it mildly alkaline.[11]

The formulation of the soap, the kind and quantity of fats or oils used, and any additional components added for aroma, color, or other purposes can all affect the pH level, though. Even though some specialized soaps, such as those made with glycerin or natural ingredients, may have a pH level that is closer to neutral (pH 7), they may still be slightly alkaline. Even though for some skin types and conditions, soap's pH level is crucial, it's important to remember that skin naturally has an acidic pH range of 4.5 to 5.5.[12] Using soap that is slightly alkaline may cause some people to experience dryness or irritation by upsetting the skin's natural pH balance. This is why some individuals choose pH-neutral or slightly acidic cleansers for their daily skin care regimen.

1.5. Moisture Content

One factor considered when determining a product's shelf life is its moisture content. In a process known as hydrolysis of soap on storage, surplus water and unsaponified fat react in high moisture content soap to produce free fatty acids and glycerol. The reaction results in the formation of soap molecules and glycerin.[13] It's crucial to make sure that all of the alkali is fully reacted with the fats or oils throughout the soap-making process to produce soap. However, minor amounts of extra alkali can result in soap that is produced with more moisture. After the saponification process, the soap can retain more moisture if it is not properly dried or cured. The finished soap is often made with a low moisture level because too much moisture can result in problems, including mold growth, a shorter shelf life, and an unappealing texture. Although this might vary, well-made soaps typically have a moisture level of between 6 and 15%.

1.6. Trace Metal

The hydrosphere naturally contains trace metals. They are harmful because they bio-accumulate, that is, build up over time in biological cells. [14] According to research on trace metals, [15] these substances can have both good and harmful effects on human health. According to Munoz-Olivas and Camara (2001), they can be divided into three categories: hazardous (Arsenic, Cadmium, Lead, Mercury, Nickel, etc.), perhaps essential (Vanadium), and necessary (Copper, Zinc, Iron, Manganese, Selenium, and Cobalt) metals. However, when the intake is overly high, the harmful effects of the final two types of metals have also been discovered. [16] During World War I, the British sprayed trace metals, which have been utilized as murderous weapons.[17] Due to their significant negative effects on ecological quality, trace metals are usually regarded as one of the major causes of environmental degradation. According to F. Islam (2013), [18] human activities like burning fossil fuels, mining, wastewater discharges from manufacturing facilities, and garbage disposal are the main causes of trace metal pollution in the environment. Trace metal concentrations can move significantly from soils and sediments to groundwater, plants, and aquatic habitats. These metals may then build up in these ecosystems after being consumed by people and other animals. The World Health Organization (WHO) requires that the trace metal concentrations in herbal products be kept within acceptable ranges. The maximum allowable limits for a few metal concentrations in cosmetics, including Lead (10 ppm), Arsenic (3 ppm), Mercury (3 ppm), and Cadmium (3 ppm), are now regulated by Health Canada.

Because they don't biodegrade, have long biological half-lives, and can amass in different bodily areas because the body doesn't have enough systems to remove them, heavy metals can be harmful to both humans and animals. Heavy metal is any metallic chemical element that is hazardous or poisonous at low concentrations and has a relative density greater than 58 km^3. Some of these are harmful to human health (As, Cd, Pb, and Hg), some are non-essential (Ni and Co), and some are necessary (Cu, Zn, Fe, and Mn). For human enzyme systems, hemoglobin synthesis, and vitamin synthesis to operate properly, essential metals must be present in very minute amounts [19]. When exposed to an elevated concentration, these metals may have harmful health effects by interfering with enzyme activity, among other things. [20] The most prevalent heavy metals are Pb and Cd, and excessive consumption of these substances has been linked to conditions affecting the heart, kidneys, neurological system, and bones. [21]

1.6.1. Source and Impact of Metal Pollution

Heavy metal toxicity has been well-documented to have negative impacts on both human health and the environment. [22] Metal poisoning has been linked to a number of mammalian malignancies, respiratory conditions, organ failures, and intellectual impairment [23]. For instance, a rise in the prevalence of some cancers has been noted in the literature [24], probably as a result of cadmium's direct obstruction of DNA mismatch repair [25]. In soaps from a number of sources, trace elements such as lead (Pb), cadmium (Cd), manganese (Mn), copper (Cu), nickel (Ni), iron (Fe), zinc (Zn), chromium (Cr), and cobalt (Co) among others, may be found.

According to Schwartz et al. (2004), many of them contain heavy metals like Cd, Cr, Ag, and Zn. The environment, our health, and our skin could be harmed by the excessive use of soaps and creams containing these ingredients. According to reports, using some skin-lightening soaps for an extended period of time might harm your nerves and cause liver poisoning and skin cancer that can be fatal.[26]
A few possible sources of heavy metals in soap are listed below:

Raw Materials

Some of the raw materials used to make soap may have traces of heavy metals. For instance, there may be trace levels of heavy metals in certain colorants, perfumes, or mineral-based compounds.

Processing Equipment

Traces of heavy metals may show up in the finished product if the equipment used in the soap-making process is dirty or poorly maintained.

Contaminated Water

Heavy metals can also be present in the water used to make soap. Heavy metals may get up in the soap if the water used is tainted with them.

Cross-Contamination

There is a chance of cross-contamination if the soap is made in a facility where heavy metals are employed in other procedures.

Pigments and Colorants

Some of the cosmetic pigments and colorants used in soaps may contain heavy metals. These may be purposefully added for their color characteristics, although doing so runs the danger of going above safe limits.

Testing and Quality Control

The presence of heavy metals in the finished product can result from insufficient testing and quality control procedures during the production process.

2. Materials and Methods

2.1. Study Area

Bangladesh is a South Asian nation that shares borders with Myanmar to the southeast and India to the west, north, and east. It is the ninth most populous nation in the world, with a population of over 160 million. The Bay of Bengal's busiest port is in Chattogram, the region's second-largest city. The country's main maritime entry point is the port of Chattogram. The largest seaport in the nation and the largest eastern port, according to the Roman geographer Ptolemy, is located there. Its divisional area is 5282.98 square kilometers, and its Statistical Metropolitan Area (SMA) is roughly 209.66 square kilometers. The divisional area has a population of approximately 6.5 million, whilst the city has around 2.5 million residents. The city of Chattogram is located between the latitudes of 21°54' and 22°54' and 22°59' N and the longitudes of 91°17' and 92°13' E. It is 12.19 kilometers (12.19 miles) north of the mouth of the Karnaphuli River in the southeast of Bangladesh.

2.2. Sample Collection

As a sample, soaps that were often used were gathered. Twelve known brands' three distinct types of soap samples were obtained from a variety of retail establishments in the Chattogram district's local markets of Agrabad, 2 no. gate, GEC, Newmarket. A total of 36 samples (beauty soap and herbal soap), three of each brand, were gathered for analysis. The name of the soap, its batch number, manufacturing date, and expiration date are displayed in Table 1.

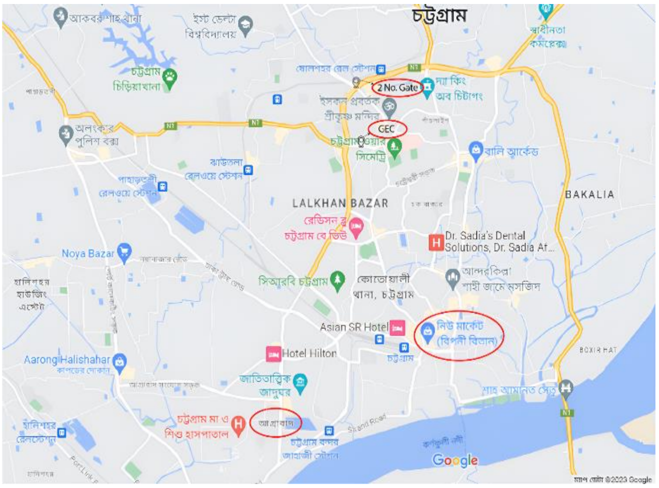

Fig. 2 Sampling location of chattogram city

Table 1. Data of the studied soap sample collected from the local market in Chattogram, Bangladesh

Sample name	Batch no	Manufacturing date	Expired date
Dove-1	8711600804357	May2023	May2025
Dove-2	8720182255716	Feb2023	Feb2026
Dove-3	8000700000005	Oct2021	Oct2024
Godrej No.1-1	GL006	Feb2023	Feb2025
Godrej No.1-2	GL001	Jan2023	Jan2025
Godrej No.1-3	GL007	Mar2023	Mar2025
Meril-1	20020056	19-02-23	18-02-25
Meril-2	22090019	19-09-22	18-09-24
Meril-3	22120064	14-12-22	13-12-24
Savlon-1	22261/1	13-11-22	12-11-24
Savlon-2	22243/1	22-10-22	21-10-24
Savlon-3	23005/1	05-01-23	04-01-25
Dettol-1	242-001.10	02-09-22	01-09-24
Dettol-2	011-114.59	18-02-23	17-02-25

Dettol-3	027-108.25	08-02-23	07-02-25
Kumarika-1	4002	20-01-23	20-01-25
Kumarika-2	4001	15-11-22	29-10-24
Kumarika-3	4003	25-03-23	18-02-25
Himalaya-1	0212100026	01-08-21	31-07-24
Himalaya-2	0212300004	16-04-23	15-04-26
Himalaya-3	0212100126	15-07-22	16-06-25
Margo-1	JLGH5B220802(iii)	Oct2022	Oct2024
Margo-2	JLGH5B230426(i)	Apr2023	Apr2025
Margo-3	JLGH5B22016(ii)	June2022	June2024
Sandalina-1	Ka/23	Jan2023	June2025
Sandalina-2	Ga/23	Mar2023	Oct2025
Sandalina-3	Gha/23	July2023	Dec2025
Neem-1	010	11-03-23	10-03-25
Neem-2	012	01-07-23	31-07-25
Neem-3	011	06-04-23	25-06-25
Cinthol-1	CH001	Jan2023	Dec2024
Cinthol-2	CL007	Sep2022	Oct2024
Cinthol-3	CH002	May2023	Apr2025
Keya-1	052.S/B	22-02-23	22-02-25
Keya-2	242.S/B	23-09-22	23-09-24
Keya-3	105.S/C	27-04-23	27-04-25

2.3. Washing

The most important step for a precise trace metal analysis and determination of physicochemical properties such as Moisture content, pH, total alkali content, and total fatty matter is washing. Following the [27] protocols, all accessories were washed. First, detergent was used to wash every glassware and then tap water was used to rinse it several times. Glassware was then immersed in an HNO_3 (5%) solution for roughly 24 hours. Before use, the product was dried at 80°C for 48 hours after being rinsed with deionized water.

2.4. Sample Preparation and Preservation

2.4.1. Preparation of Soap Sample for Determination of Total Alkali Content

At first, 5gm of soap sample is taken in a beaker, and 100ml of hot (80^0C) distilled water is added to the sample to dissolve the soap sample. For acidity, around 40ml of 0.5N HNO3 is added. The combination is heated to 800C in a water bath until a layer of fatty acids rises to the top of the liquid. In order to solidify the fatty acids, it is chilled in ice water at -4°C. After the fatty acids were separated by filtration, the residual fatty acids were extracted from the aqueous solution using a separating funnel and 50 milliliters of chloroform. Using methyl orange as an indicator, 10 milliliters of the aqueous solution were titrated against 0.5N NaOH after being measured. [5]

Calculation

Total volume of the aqueous solution =V=_________ml
10 ml of aqueous solution required t ml of NaOH
V ml of aqueous solution requires = V x t /10 = A ml.
Amount of NaOH required by acid in aqueous solution =A ml
Volume of HNO_3required, B ml =A x Normality of NaOH / Normality of HNO_3
Volume of HNO_3 required for neutralizing NaOH = C=40 – B
Amount of NaOH in 1000 cc of soap solution (E) = (C x 40 x Normality of HNO_3g)/1000
250 cc of soap solution contains (F) = (E x 250) / 1000 g
2 NaOH ------- Na_2O + H_2O
80gram of NaOH 62 g of Na_2O
F g of NaOH requires (Y) = (62 x F) / (80) g of Na_2O
Weight of Soap taken = 5 g
% of alkalinity = (Y x 100) / w = _______________

2.4.2. Preparing Soap Sample for Total Fatty Matter in Soap

For total fatty matter content, 5gm of soap sample is dissolved in 100ml hot (80^0C) distilled water by using a magnetic stirrer machine. Using a magnetic stirrer machine, 5g of soap sample is dissolved in 100 ml of hot (800C) distilled water to determine the total fatty matter concentration. Add around 40 milliliters of 0.5N HNO3 to make it acidic. The mixture is heated to 800C in a water bath until a layer of fatty acids floats over the solution. To solidify the fatty acids, it is chilled in ice water (-4 0C). After the fatty acids were separated, the residual fatty acids were extracted from the aqueous solution using a separating funnel and 50 milliliters of chloroform. After combining the separated fatty matter and evaporating the solvent, the yield was recorded.[28]

Calculation

Weight of the china dish (x) = ______________

Weight of china dish + Soap after drying (y) =_______________

Weight of soap sample = 5 g

% of fatty matter = {(y – x) x 100}/ Weight of soap sample = ______________

2.4.3. Moisture Content

Using the standard method of AOCS Db 1-48, the moisture content of soap samples was determined. 5.0 g of samples were taken in a dried and tarred moisture dish and dried in an oven for 2 h at 101°C. This process was repeated until the weight became constant. [28]

The moisture content was determined by employing the following formula:

% Moisture content = (Cs - Ch / Cs – Cw) × 100

Where,

Cw = weight of the crucible

Cs=weight of crucible +sample

Ch = weight of crucible +sample after floating.

2.4.4. Determination of pH in Soap Sample

Weights of Soap (1.0 g) and distilled water (99.0 g) were taken. Distilled water was then boiled to a temperature of 80 °C. The distilled water was then mixed with soap, and the mixture was thoroughly stirred using a magnetic stirrer machine. Next, the solution was cooled to 40°C, and the pH was determined using a pH meter. (Preparation of Soaps by Using Different Oil and Analyze Their Properties, 2019). When determined, the pH of the soap must be at 40°C; if the temperature is too high, the solution becomes thicker, and it is difficult to measure the pH. [11]

2.4.5. Heavy Metal Analysis

The standard protocol for sample preparation for trace metal analysis was followed. The dried samples were first weighed into a triplicate porcelain crucible at a weight of 10g each. The samples were then dry-ashed in a muffle furnace at stepwise temperature increases of up to 650°C until the carbon was eliminated. It took 8–10 hours to remove all of the carbon completely. In 1M 5ml HNO3, the prepared ash was dissolved. The sample was heated in a water bath for 20 minutes. The sample was then chilled before being filtered in a 25ml measuring flask using man filter paper no. 41. Distilled water was used to dilute the sample up to 25ml. After that, the sample was kept in a vial in a 4°C refrigerator. Atomic absorption spectrophotometer analysis was performed on the samples.

2.4.6. Blank sample Preparation

To prevent contamination of the samples and the chemicals utilized, reagent blanks (laboratory blanks) have been prepared during the digestion phase of the pre-concentration process of soap. Similar to sample preparation, blank sample preparation involves adding no samples to the digestion and pre-concentration vessels. Reagent blanks are rated as samples and diluted with the same factor following digestion and pre-concentration. After that, they are examined before the primary samples. Each set of digested and pre-concentrated samples has been adjusted using its own reagent blanks and blank samples.

2.5. Precautions

The contamination of the sample during sample pretreatment (weighting, cutting, and digestion) is one of the main issues with sample preparation. Therefore, many measures are taken to prevent contamination, such as cleaning all bottles and glassware with an acidic solution (20% v/v) and deionized water before use; additionally, the air in the lab or the acid mixture used for digestion may be contaminated. Reagent blanks have, therefore, been made in each set in order to check for errors from any of the various causes that have been listed.

2.6. Health Risk Assessment

According to [29], health risk assessment refers to techniques for determining the likelihood of any given probable quantity of detrimental health impacts occurring during a predetermined time frame. It is a multi-step process that includes data collection and interpretation, exposure assessment, toxicity assessment, and risk identification. The classification of each contaminant’s health risk as carcinogenic or non-carcinogenic is often based on the evaluation of the risk level. The United States Environmental Protection Agency (USEPA) established carcinogenic and non-carcinogenic risk models, which were computed in this study. The possible health risks to consumers were evaluated using the USEPA-proposed threshold values.

Table 2. Parameters for exposure of metals in cosmetics samples used in the study

Exposure factor	Unit	Value
Exposure-point concentration (CS)	mg/kg	x
Exposure frequency (EF)	days/year	350
Exposure duration (ED)	year	30
Average time for non-carcinogens (AT)	days	25550
Body weight (BW)	kg	70
Exposed skin area (SA)	cm^2	5700
Adherence factor (AF)	mg/cm^2	0.07
Dermal absorption fraction (ABS)	-	0.001
Unit conversion factor (CF)	$kg\ mg^{-1}$	10^{-6}

2.6.1. Estimated Chronic Daily Intake of Trace Metals (CDI)

The assessment of health risks is investigated by direct skin contact with makeup particles. When target analytes are exposed to humans, three main pathways could happen (a) direct ingestion, (b) inhalation through the mouth and nose, and (c) skin absorption. Only dermal absorption is the most significant factor for metals in the cosmetics industry, [30] for skin care soap. This pathway was taken into consideration while calculating the exposure dosage and Chronic Daily Intake (CDI) using equation (1). Table 2 provides a full explanation for each parameter. The equation is adapted from the USEPA. [31]

The formula for calculating dermal absorption:
Exposure pathway Calculation formula:

Dermal Contact CDI dermal =

$$(CS \times SA \times AF \times ABS \times EF \times ED \times CF) / (BW \times AT) \quad (1)$$

2.6.2. Non-carcinogenic risk (NCR)

The non-carcinogenic risk, or hazard quotient, or HQ, of each metal in the cosmetic samples was determined. The term "HQ" refers to the relationship between the chronic reference dose (RfD) of a toxicant (mg/kg/day) and the exposure to hazardous chemicals. Non-carcinogenic risk,

$$HQ = CDI_{dermal} / RfD_{dermal} \quad (2)$$

The dermal reference doses are 0.01, 0.003, 0.003, 0.3, 0.02, 0.03, 0.003, and 0.36 mg/kg/day for Cd, Pb, Cr, Zn, Co, Ni, Cr and Fe, respectively [32] If HQ < 1, the exposed population is unlikely to experience obvious adverse effects. There may be a health risk [33] if HQ > 1; thus, appropriate actions and preventative measures must be implemented. The hazard index (HI) was created to calculate the risk that several trace metals (TM) pose to human health.36 The total of all TMs' hazard quotients, which were determined using the equation, is the hazard index.[34]:

$$HI = \Sigma HQ = HQ_{Ni} + HQ_{Mn} + HQ_{Cr} + HQ_{Cd} + HQ_{Pb} \quad (3)$$

2.6.3. Carcinogenic Risk (CR)

Carcinogenic risk refers to the increased likelihood of developing cancer over time as a result of chemical exposure under certain conditions. [35, 36] The CR value must be calculated to determine whether consumers are likely to suffer from cancer, and this can be evaluated using an equation.

$$CR = CDI \times SF \quad (4)$$

Where CDI is the chronic daily intake of carcinogens (mg kg^{-1} d^{-1}), and SF is the slope factor of hazardous substances (mg kg^{-1} d^{-1})
Note: x = metal mean concentration in a given sample.

2.7. Statistical Analysis

Geospatial analysis and sample location mapping were done by using Arc GIS (Version 10.1). Besides, MS Excel (2007) was used for groundwater data analysis and presentation.

Table 3. Physicochemical properties of important parameters of soaps

Sample ID	Moisture Content (%)	pH	Total AlkaliContent (%)	Total FattyMatter (%)
Dove-1	10.67	**7.3**	1.65	**60.00**
Dove-2	10.72	7.3	1.63	60.06
Dove-3	10.73	7.3	1.64	60.01
Godrej-1	12.02	9.8	1.67	76.11
Godrej-2	12.00	9.7	1.66	76.05
Godrej-3	12.01	9.8	1.67	76.13
Meril-1	9.64	9.6	1.46	73.53
Meril-2	9.62	9.6	1.47	73.79
Meril-3	9.61	9.5	**1.45**	73.66
Savlon-1	11.15	9.6	2.04	75.15
Savlon-2	11.13	9.5	2.08	75.23
Savlon-3	11.13	9.5	2.05	75.18
Dettol-1	10.97	10.1	1.79	73.64
Dettol-2	10.98	10.0	1.77	73.78
Dettol-3	10.94	10.0	1.76	73.59
Kumarika-1	**8.40**	9.4	2.43	64.03
Kumarika-2	8.42	9.4	2.40	64.10
Kumarika-3	8.43	9.4	2.42	64.12
Himalaya-1	9.10	9.9	2.54	75.39
Himalaya-2	9.24	10.0	2.52	75.38
Himalaya-3	9.22	10.0	2.55	75.45
Margo-1	14.78	9.6	2.09	71.17
Margo-2	14.75	9.6	2.09	71.15
Margo-3	14.77	9.6	2.08	71.18
Sandalina-1	9.98	10.2	2.29	**79.48**

Sandalina-2	9.91	10.2	2.35	79.45
Sandalina-3	9.96	10.2	2.33	79.42
Neem-1	15.10	9.7	1.98	70.66
Neem-2	15.14	9.5	2.00	70.60
Neem-3	**15.11**	9.6	1.97	70.68
Cinthol-1	13.56	10.1	2.61	67.54
Cinthol-2	13.63	10.0	**2.64**	67.47
Cinthol-3	13.62	10.0	2.62	67.53
Keya-1	14.79	**10.3**	2.56	65.35
Keya-2	14.58	10.2	2.55	65.37
Keya-3	14.78	10.2	2.59	65.28

3. Results And Discussion

3.1. Analysis of Physicochemical Properties

We studied the physicochemical properties of commercial soaps sold in the Chattogram market. The current study evaluated the quality of 36 soap samples. The physicochemical examination findings represent the soap's qualities, as indicated in (Table 3).

3.2. Analysis of Moisture Content

Moisture content is a metric used to determine the shelf life of a product. Excess moisture in soap can react with unsaponified fat, resulting in free fatty acid and glycerol during storage, known as hydrolysis. The existence of moisture is typically present in trace amounts in liquids, particularly water. As a result of moisture, the content is presented in Figure 3.

The moisture content of soap samples was found to be in the range of 8.40-15.11%. The Neem-3 sample had the highest moisture content (15.11%), and Kumarika-1 exhibited the lowest moisture content (8.40%).

Moisture Content in some reported soap samples falls within the boundaries of the Encyclopedia of Industries Chemical Analysis. (10% - 15%). According to our experimental results, all soap samples.

3.3. Analysis of pH:

The pH in the examined samples ranged from 7.3 to 10.3. The pH result is presented in Figure 4. The results indicate that Dove soap has the lowest pH (7.3), and Keya-1 soap has the highest (10.3). Higher pH readings imply that soaps are damaging to the skin. Soap's alkaline properties in aqueous solutions operate as a barrier against germs and viruses by neutralizing the body's protective acid mantle.

Healthy skin has a pH range of 5.4 to 5.9. Soap with pH levels in this range is best, but around 7 pH is also a good soap, like Dove. [37] Dove, however, has a neutral pH of 7.3 that's balanced with our skin to avoid any damage. It actively cares for our skin, adding skin-natural nutrients to keep it feeling healthy.

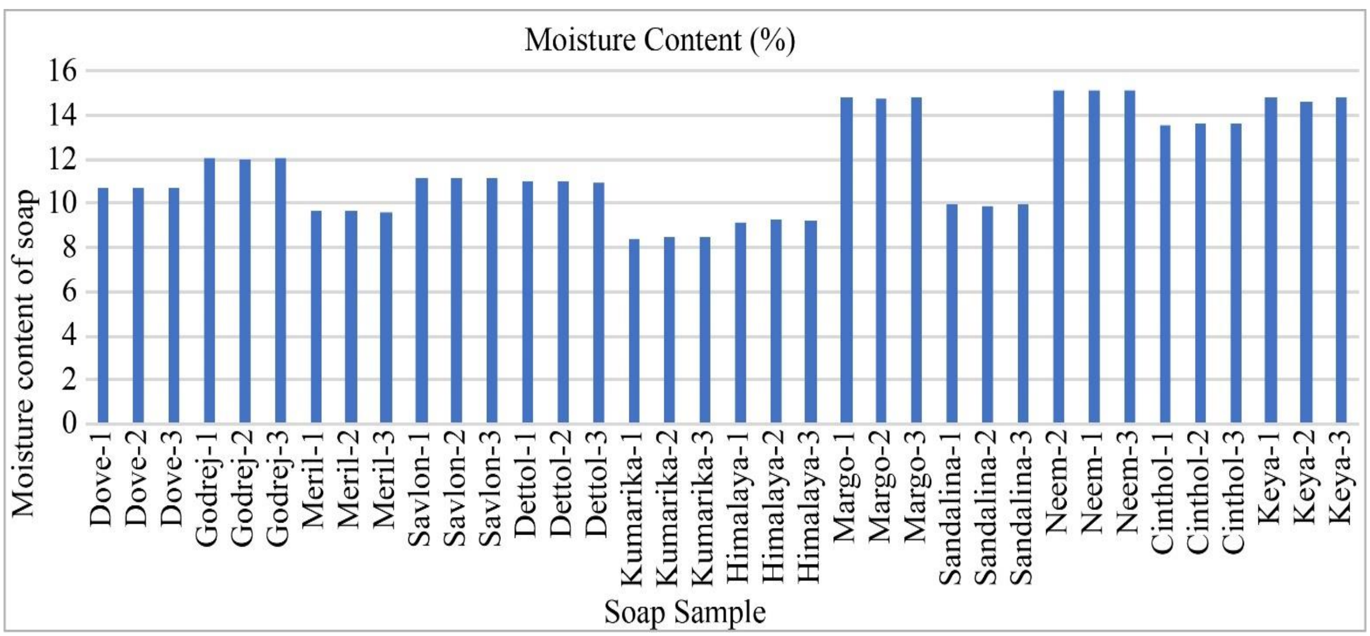

Fig. 3 Graphical representation of Moisture content (%)

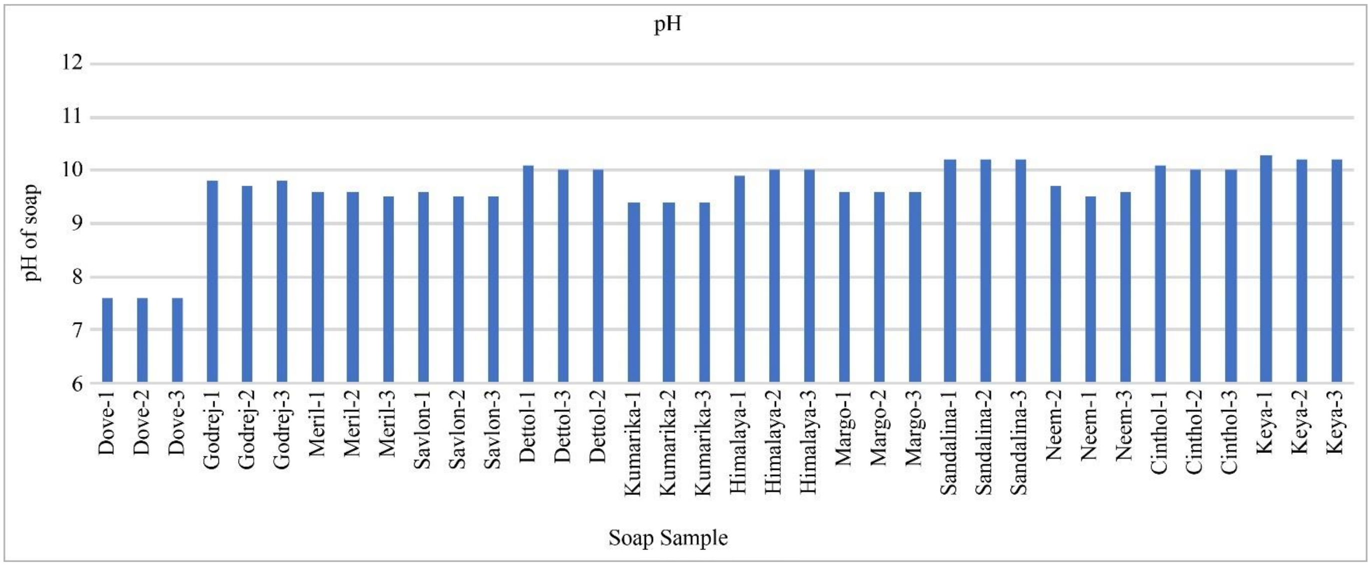

Fig. 4 Graphical representation of pH value

3.4. Analysis of Total Alkali

The amount of alkaline substance present determines the overall alkalinity of soap. They include alkaline. Components include hydroxides, sodium (II) oxide, carbonates, and bicarbonates. Total alkali Content is one factor that influences the abrasiveness of any given soap. The range values of the data in Figure 5 range from 1.45 to 2.64 percent, with Cinthol-2 having the highest total. The alkali content value is 2.64%, with Meril-3 having the lowest value of 1.45%. The outcomes fall. Within the normal values of 5% max declared by the ISO standard [BIS] and 2% max declared according to ISO standard. This demonstrates that the soap will not be harsh on the skin [38]. All The soaps studied were found to have modest overall alkali concentrations, making them good for the Skin and Environment.

3.5. Analysis of Total Fatty Matter

The TFM data obtained in this investigation are displayed in Figure 6. Dove-1 has the lowest TFM (60.00%), whereas Sandalina-1 has the greatest (79.48%). This study found less TFM in soaps compared to the previously reported studies (74%-92%). TFM discrepancies may be caused by variances in fatty material quantities or saponification methods. The mixture contains unreacted NaOH, which accounts for the lower TFM value. Dry skin requires soap with a high TFM concentration (80%), which rehydrates the skin and functions as a lubricant during the day. TFM of Sandalina, Godrej No.1 Savlon and Himalaya can be considered as Grade 1 category soaps. Because Dove is a Syndet, its Total Fatty Matter (TFM) might not be greater than 60%, and it falls in the Grade 3 category soap.

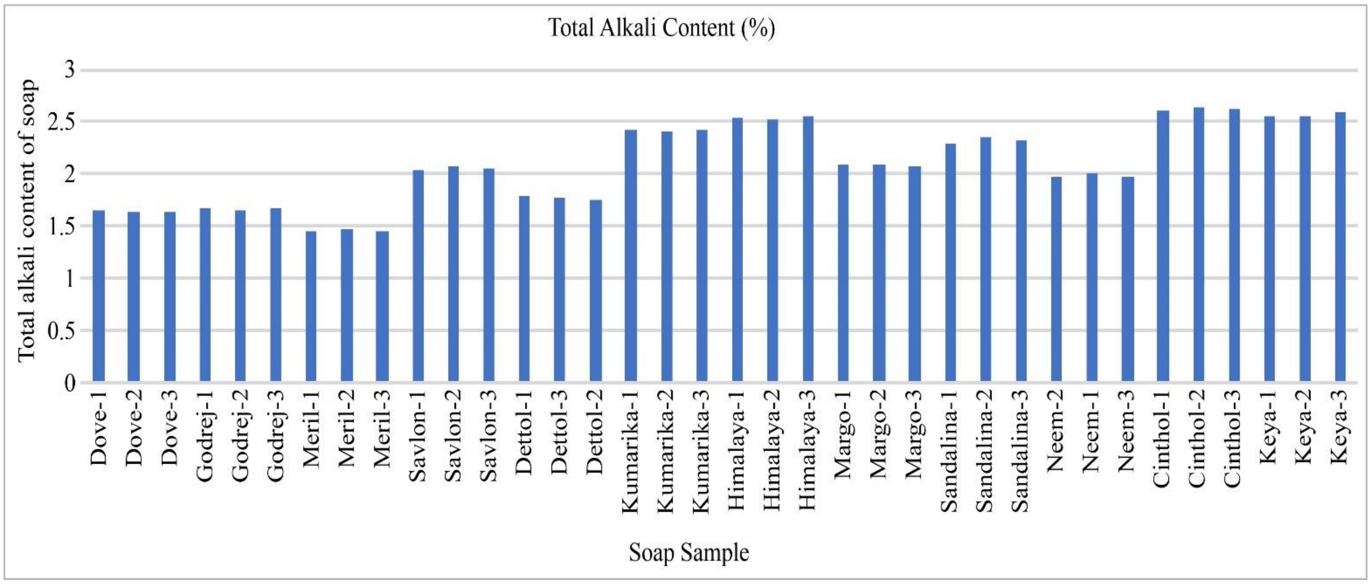

Fig. 5 Graphical representation of Total Alkali Content

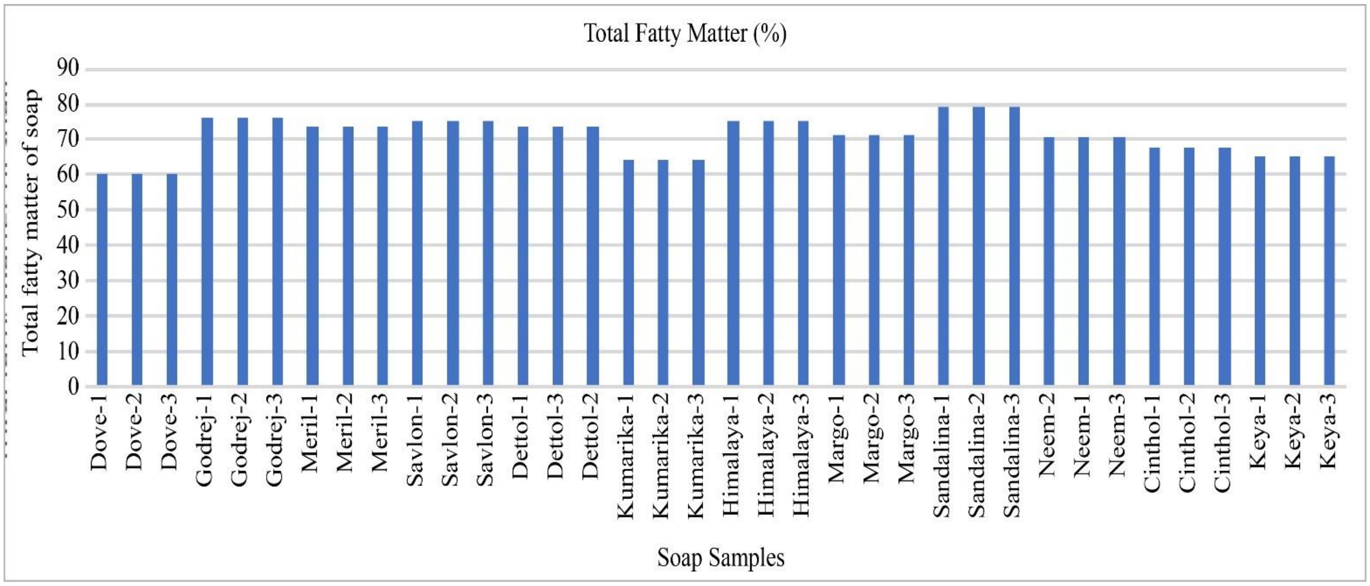

Fig. 6 Graphical representation of Total Fatty matter

3.6. Analysis of Trace Metals in Soap

The concentration of 08 trace metals for each sample found in soap was studied and compared to standard values and several international standards and guidelines. Soap that both men and women often use trace metals have been found in it. Long-term dermal absorption of trace metals into the body has been linked to a number of health issues. [39, 40]. Table 4 provides a summary of the soap's trace element composition as determined by triplicates. The results show that the Fe content ranged from 0.56±0.02 to 1.98±0.03 mg/kg, with the Savlon-1 sample having the lowest concentration at 0.56±0.02 mg/kg and the Himalaya-1and Himalaya-2 samples having the greatest value at 1.98±0.03 mg/kg. Fe is an essential component that promotes the production of hemoglobin, healthy muscular growth, and the prevention of anemia.

On the other hand, an excess of Fe can cause vomiting, diarrhea, stomach pain, and constipation [41, 42]. Although we were unable to compare the concentration of Fe using any standards or permissible upper limits, the amount of Fe in our sample was not excessive enough to pose a threat to health. So, it is thought that the existing Fe content in our soap samples was safe. Another essential component for wellness is zinc. It is a crucial micronutrient and trace element for all living things. Due to its significance in nucleic acid synthesis, it can be found in nearly every cell and occurs in a wide variety of enzymes [41, 42]. It was discovered that the Zn concentration ranged from 0.06±0.01 to 1.33±0.01 mg/kg. Zn present in samples of Kumarika-1 was 1.33±0.01, and in Dove, the concentration was 0.06±0.01 mg/kg. The WHO states that the allowable limit for Zn for cutaneous ingestion should be less than 20 mg/kg [43]. Therefore, it can be shown that the Zn concentration in our sample is within safe limits.

The WHO's allowed limit for Pb is 10 mg/kg, while the limit for Co is 0.01 mg/kg [43]. Fortunately, it was found that none of the samples tested positive for Pb or Co. Additionally, it was discovered that the content of the other two cancer-causing metals (Cd and Ni) was below the detection level. However, the sample also included two additional carcinogenic metals (Cr and Mn), with values ranging from 0.07±0.01 to 7.45±0.01 mg/kg for Cr and 0.06±0.01 to 0.18±0.01 mg/kg for Mn. The allowed limit for Cr is 1 mg/kg, according to the WHO and EU.[43] The highest level of Cr 7.45±0.01 mg/kg was found in the Himalaya-3 sample, above both the WHO and EU permitted limits. Additionally, the values of Cr in Himalaya-1, Himalaya-2, Kumarika-1, Kumarika-2 and Kumarika-3 soap samples were 7.37±0.01, 7.39±0.01, 5.55±0.01, 5.43±0.01, and 5.45±0.01 mg/kg, respectively, exceeded the allowable range. In actuality, the levels of Cr in other samples were within acceptable bounds.

The highest concentration of Mn was discovered in the Sandalina-1 sample, which had a concentration of 0.18±0.01 mg/kg, and the lowest value, which was discovered in samples of Himalaya soap, had a concentration of 0.06±0.01 mg/kg. Every Mn concentration is within the acceptable range.

The fact that the metal concentrations of Zn, Cr, Mn, and Fe were within the acceptable level as per Health Canada is also highlighted [44]. As indicated in Table 4, when the concentrations of the trace metals in the soap under study are combined, they are in the following order: Cr > Fe > Zn > Mn, with mean values of 1.80±0.01; 1.25±0.03; 0.63±0.01; and 0.12±0.01 mg/kg, respectively. Table 5 includes the concentration range, standard deviation, and several international standards and their recommendations.

Table 4. Concentration (mg/kg) of trace metals in soap samples

Sample ID	**Fe**			**Co**	**Zn**			**Cr**			**Mn**			**Ni**	**Pb**	**Cd**
Dove-1	0.76	±	0.04	BDL	**0.06**	±	**0.01**	0.56	±	0.01	0.08	±	0.01	BDL	BDL	BDL
Dove-2	0.79	±	0.04	BDL	**0.06**	±	**0.01**	0.56	±	0.02	0.08	±	0.01	BDL	BDL	BDL
Dove-3	0.77	±	0.04	BDL	**0.06**	±	**0.01**	0.57	±	0.01	0.07	±	0.01	BDL	BDL	BDL
Godrej-1	1.09	±	0.01	BDL	0.45	±	0.01	0.31	±	0.01	BDL	±	0.01	BDL	BDL	BDL
Godrej-2	1.11	±	0.01	BDL	0.49	±	0.01	0.32	±	0.01	BDL	±	0.01	BDL	BDL	BDL
Godrej-3	1.09	±	0.01	BDL	0.48	±	0.01	0.31	±	0.01	BDL	±	0.01	BDL	BDL	BDL
Meril-1	1.71	±	0.01	BDL	1.08	±	0.01	0.27	±	0.01	0.11	±	0.01	BDL	BDL	BDL
Meril-2	1.69	±	0.01	BDL	1.11	±	0.01	0.26	±	0.02	0.14	±	0.01	BDL	BDL	BDL
Meril-3	1.68	±	0.01	BDL	1.09	±	0.01	0.24	±	0.04	0.13	±	0.01	BDL	BDL	BDL
Savlon-1	**0.56**	±	**0.02**	BDL	0.15	±	0.01	0.21	±	0.01	0.06	±	0.01	BDL	BDL	BDL
Savlon-2	0.59	±	0.02	BDL	0.23	±	0.01	0.22	±	0.01	0.06	±	0.01	BDL	BDL	BDL
Savlon-3	0.58	±	0.02	BDL	0.19	±	0.01	0.22	±	0.01	0.06	±	0.01	BDL	BDL	BDL
Dettol-1	0.95	±	0.01	BDL	0.37	±	0.01	0.09	±	0.01	0.13	±	0.01	BDL	BDL	BDL
Dettol-2	1	±	0.01	BDL	0.35	±	0.01	**0.07**	±	**0.01**	0.13	±	0.01	BDL	BDL	BDL
Dettol-3	0.99	±	0.01	BDL	0.35	±	0.01	0.08	±	0.01	0.14	±	0.01	BDL	BDL	BDL
Kumarika-1	1.15	±	0.07	BDL	**1.33**	±	**0.01**	5.55	±	0.01	0.09	±	0.01	BDL	BDL	BDL
Kumarika-2	1.18	±	0.07	BDL	1.29	±	0.01	5.43	±	0.01	0.08	±	0.01	BDL	BDL	BDL
Kumarika-3	1.17	±	0.07	BDL	1.31	±	0.01	5.45	±	0.01	0.09	±	0.01	BDL	BDL	BDL
Himalaya-1	**1.98**	±	**0.03**	BDL	1.22	±	0.01	7.37	±	0.01	0.06	±	0.01	BDL	BDL	BDL
Himalaya-2	**1.98**	±	**0.03**	BDL	1.22	±	0.01	7.39	±	0.01	0.06	±	0.01	BDL	BDL	BDL
Himalaya-3	1.96	±	0.03	BDL	1.25	±	0.01	**7.45**	±	**0.01**	**0.06**	±	**0.01**	BDL	BDL	BDL
Margo-1	0.87	±	0.04	BDL	0.19	±	0.01	0.15	±	0.01	0.09	±	0.01	BDL	BDL	BDL
Margo-2	0.84	±	0.04	BDL	0.17	±	0.01	0.17	±	0.01	0.09	±	0.01	BDL	BDL	BDL
Margo-3	0.83	±	0.04	BDL	0.21	±	0.01	0.18	±	0.01	0.1	±	0.01	BDL	BDL	BDL
Sandalina-1	1.92	±	0.03	BDL	0.53	±	0.01	BDL	±	0.01	**0.18**	±	**0.01**	BDL	BDL	BDL
Sandalina-2	1.91	±	0.03	BDL	0.55	±	0.01	BDL	±	0.01	0.17	±	0.01	BDL	BDL	BDL
Sandalina-3	1.95	±	0.03	BDL	0.56	±	0.01	BDL	±	0.01	0.17	±	0.01	BDL	BDL	BDL
Neem-1	1.15	±	0.01	BDL	1.27	±	0.01	BDL	±	0.01	0.13	±	0.01	BDL	BDL	BDL
Neem-2	1.11	±	0.01	BDL	1.22	±	0.01	BDL	±	0.01	0.13	±	0.01	BDL	BDL	BDL
Neem-3	1.18	±	0.01	BDL	1.29	±	0.01	BDL	±	0.01	0.13	±	0.01	BDL	BDL	BDL
Cinthol-1	1.09	±	0.02	BDL	0.64	±	0.01	BDL	±	0.01	0.14	±	0.01	BDL	BDL	BDL
Cinthol-2	1.07	±	0.02	BDL	0.62	±	0.01	BDL	±	0.01	0.13	±	0.01	BDL	BDL	BDL
Cinthol-3	1.09	±	0.02	BDL	0.61	±	0.01	BDL	±	0.01	0.11	±	0.01	BDL	BDL	BDL
Keya-1	1.78	±	0.03	BDL	0.13	±	0.01	BDL	±	0.01	0.15	±	0.01	BDL	BDL	BDL
Keya-2	1.55	±	0.03	BDL	0.15	±	0.01	BDL	±	0.01	0.16	±	0.01	BDL	BDL	BDL
Keya-3	1.76	±	0.03	BDL	0.11	±	0.01	BDL	±	0.01	0.16	±	0.01	BDL	BDL	BDL
Mean SD	1.25	±	0.03	NA	0.63	±	0.01	1.80	±	0.01	0.12	±	0.01	NA	NA	NA

BDL= Below the detection limit.

The bold value indicates the maximum and minimum concentration of trace metals.

Table 5. Summary of the range and mean value of trace metals (mg/kg) in soap samplesand different standards and guidelines

SampleID	**Fe**	**Co**	**Zn**	**Cr**	**Mn**	**Ni**	**Pb**	**Cd**
Max	1.98±0.03	BDL	1.33±0.01	7.45±0.01	0.18±0.01	BDL	BDL	BDL
Min	0.56±0.02	BDL	0.06±0.01	0.07±0.01	0.06±0.01	BDL	BDL	BDL
Mean(±SD)	1.25	NA	0.63	1.8	0.12	NA	NA	NA
WHO (mg/kg)	-	<0.1	<20	1	-	-	10	0.3
US EPA (mg/kg)	-	-	<18	1	-	<0.1	<0.5	<0.5
EU (mg/kg)	-	<0.02	<20	1	-	-	0.5	0.5

Graphical representation of the concentration of trace metals insoaps:

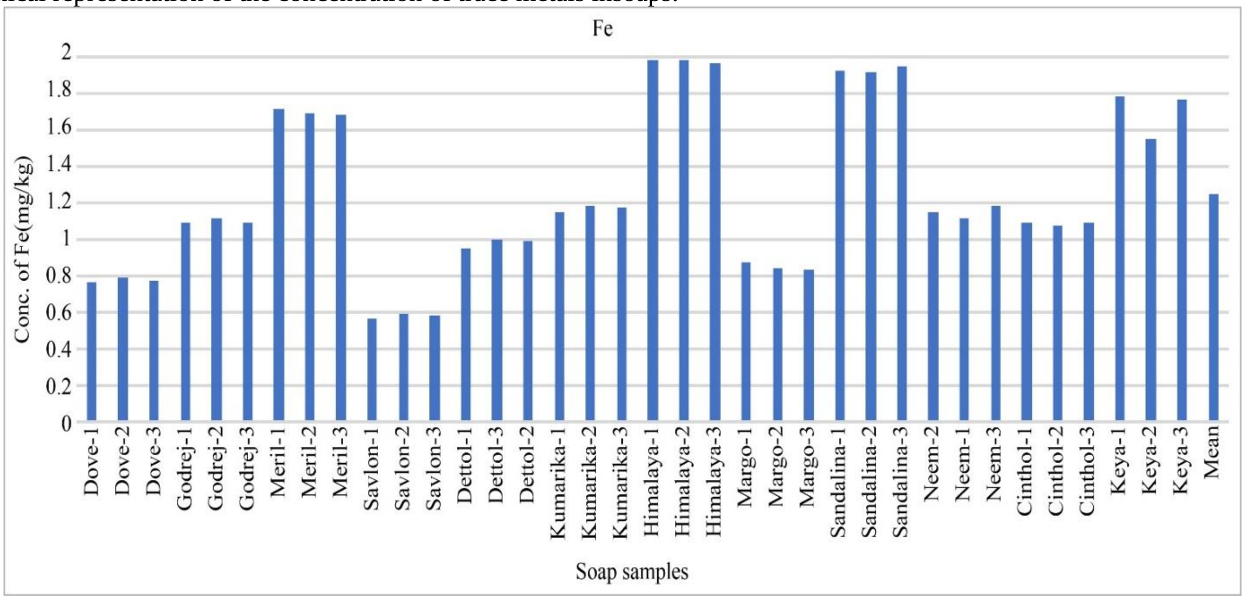

Fig. 7 Concentration of Fe in soaps

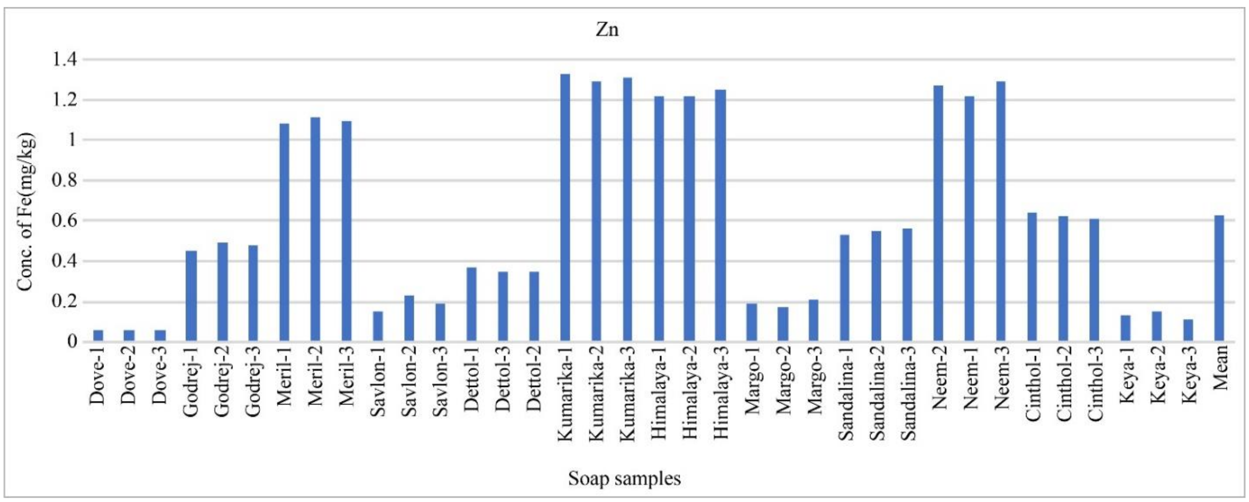

Fig. 8 Concentration of Zn in soap

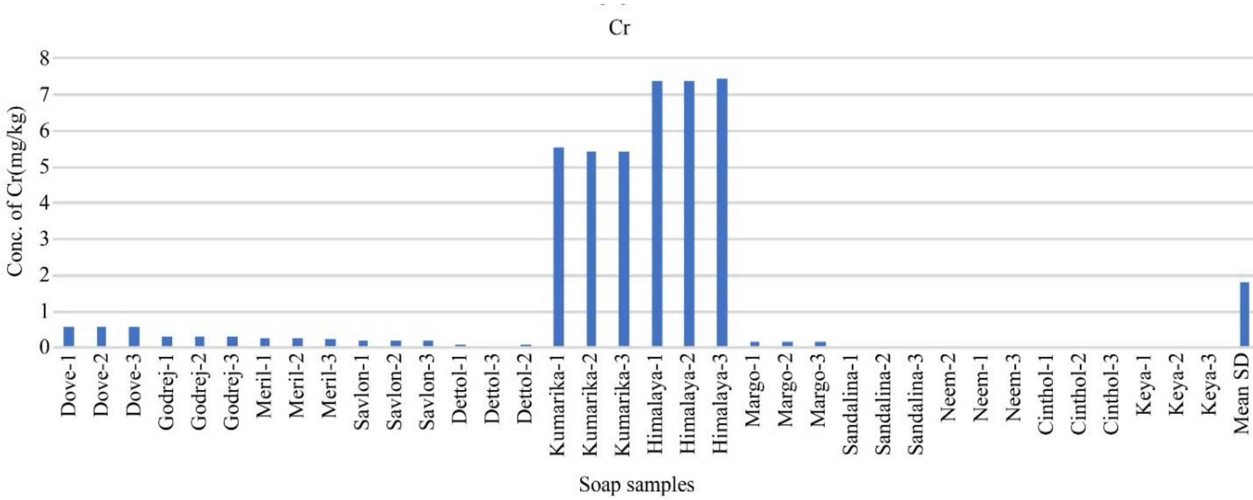

Fig. 9 Concentration of Cr in soaps

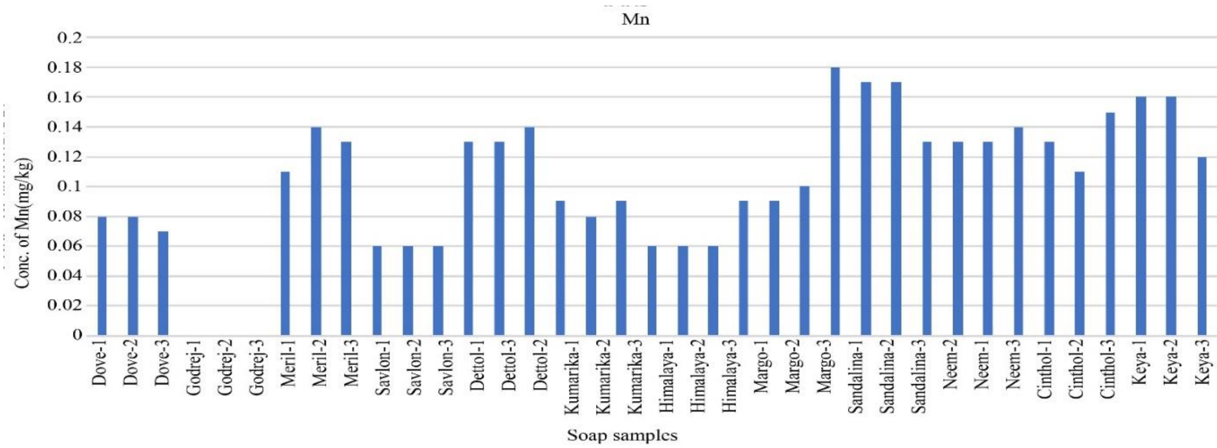

Fig. 10 Concentration of Mn in soaps

Table 6. CDI of metals mg/kg/day

Sample ID	Fe	Zn	Cr	Mn
Dove-1	1.78E-09	1.40E-10	1.31E-09	1.87E-10
Dove-2	1.85E-09	1.40E-10	1.31E-09	1.87E-10
Dove-3	1.80E-09	1.40E-10	1.33E-09	1.64E-10
Godrej-1	2.55E-09	1.05E-09	7.25E-10	BDL
Godrej-2	2.60E-09	1.15E-09	7.49E-10	BDL
Godrej-3	2.55E-09	1.12E-09	7.25E-10	BDL
Meril-1	4.01E-09	2.53E-09	6.32E-10	2.57E-10
Meril-2	3.96E-09	2.60E-09	6.08E-10	3.28E-10
Meril-3	3.94E-09	2.55E-09	5.62E-10	3.04E-10
Savlon-1	1.31E-09	3.51E-10	4.91E-10	1.40E-10
Savlon-2	1.38E-09	5.38E-10	5.15E-10	1.40E-10
Savlon-3	1.36E-09	4.45E-10	5.15E-10	1.40E-10
Dettol-1	2.23E-09	8.66E-10	2.11E-10	3.04E-10
Dettol-2	2.34E-09	8.19E-10	1.64E-10	3.04E-10
Dettol-3	2.32E-09	8.19E-10	1.87E-10	3.28E-10
Kumarika-1	2.69E-09	3.11E-09	1.30E-08	2.11E-10
Kumarika-2	2.76E-09	3.02E-09	1.27E-08	1.87E-10
Kumarika-3	2.74E-09	3.07E-09	1.28E-08	2.11E-10
Himalaya-1	4.64E-09	2.85E-09	1.72E-08	1.40E-10
Himalaya-2	4.64E-09	2.85E-09	1.73E-08	1.40E-10
Himalaya-3	4.59E-09	2.93E-09	1.74E-08	1.40E-10
Margo-1	2.04E-09	4.45E-10	3.51E-10	2.11E-10
Margo-2	1.97E-09	3.98E-10	3.98E-10	2.11E-10
Margo-3	1.94E-09	4.91E-10	4.21E-10	2.34E-10
Sandalina-1	4.50E-09	1.24E-09	BDL	4.21E-10
Sandalina-2	4.47E-09	1.29E-09	BDL	3.98E-10
Sandalina-3	4.57E-09	1.31E-09	BDL	3.98E-10
Neem-1	2.69E-09	2.97E-09	BDL	3.04E-10
Neem-2	2.60E-09	2.85E-09	BDL	3.04E-10
Neem-3	2.76E-09	3.02E-09	BDL	3.04E-10
Cinthol-1	2.55E-09	1.50E-09	BDL	3.28E-10
Cinthol-2	2.51E-09	1.45E-09	BDL	3.04E-10
Cinthol-3	2.53E-09	1.43E-09	BDL	2.57E-10
Keya-1	4.17E-09	3.04E-10	BDL	3.51E-10
Keya-2	3.63E-09	3.51E-10	BDL	3.74E-10
Keya-3	4.12E-09	2.57E-10	BDL	3.74E-10
Total Intake	1.05E-07	5.24E-08	1.02E-07	8.05E-10

3.7. Health Risk Assessment

Trace elements in various media can enter the human body via three primaries Exposure through eating, inhalation, and skin contact poses both carcinogenic and non-carcinogenic health concerns. [42] For assessing health hazards. Associated with the habitual use of soaps by females, we assessed the exposure route. It is connected to the dermal contact alone.

3.8. Implication of the calculated Chronic Daily Intake (CDI)

Their daily intake determines the toxicity of trace metals to humans. [45] The CDI of five metals (Fe, Mn, Cu, Zn, and Cr) was determined based on their mean concentrations. Table 6 displays the CDI values for the metals under study. Total daily intake of Fe, Cu, Zn, Cr, and Mn were computed as 6.99E-08, 1.10E-08, 1.70E-08, 2.37E-08, and 4.17E-09 mg/kg/day, respectively. In soap samples, CDI values fall in the following order: Fe > Cr > Zn > Cu > Mn. The CDI for Cd, Pb, and Ni was not calculated due to the lack of a sample.

3.9. Non-Carcinogenic Risk (NCR)

Non-Carcinogenic Risk (NCR) evaluation evaluates the likelihood of negative health effects over a specific period [31]. The health concerns of populations regarding soap use are evaluated using the Hazard Quotient (HQ), which compares the determined dosage of a pollutant to a Reference Dose Level (RfD). The USEPA has demonstrated that if the HQ is greater than one, the exposed population may suffer negative consequences. Table 7 shows 38 HQ of the five metals examined for each sample. We did not calculate HQ values for Pb, Cd, Co, or Ni due to their lack in the soap samples we tested. It is seen from Table 7. Table 7 shows that all metals in beauty soap samples have HQ values < 1, indicating no major health risk for Bangladesh people through dermal absorption. The Hazard Index (HI) value represents the non-carcinogenic impacts of numerous components.

Table 8 shows that using selected soap resulted in HI < 1, demonstrating consumer safety.

Table 7. HQ value for five studied metals

Sample ID	HQFe	HQzn	HQCr	HQMn	HI
Dove-1	4.94E-09	4.67E-10	4.37E-07	1.34E-10	4.43E -07
Dove-2	5.14E-09	4.67E-10	4.37E-07	1.34 E-10	4.43E -07
Dove-3	5.00E-09	4.67E-10	4.43E-07	1.17 E-10	4.48E -07
Godrej-1	7.08E-09	3.50E-09	2.42E-07	ND	2.53E -07
Godrej-2	7.22E-09	3.83E-09	2.50E-07	ND	2.61E -07
Godrej-3	7.08E-09	3.73E-09	2.42E-07	ND	2.53E -07
Meril-1	1.11E-08	8.43E-09	2.11E-07	1.84 E-10	2.31E -07
Meril-2	1.10E-08	8.67E-09	2.03E-07	2.34 E-10	2.23E -07
Meril-3	1.09E-08	8.50E-09	1.87E-07	2.17 E-10	2.06E -07
Savlon-1	3.64E-09	1.17E-09	1.64E-07	1.00 E-10	1.69E -07
Savlon-2	3.83E-09	1.79E-09	1.72E-07	1.00 E-10	1.78E -07
Savlon-3	3.78E-09	1.48E-09	1.72E-07	1.00 E-10	1.77E -07
Dettol-1	6.19E-09	2.89E-09	7.03E-08	2.17 E-10	7.94E-08
Dettol-2	6.50E-09	2.73E-09	5.47E-08	2.17 E-10	6.39 E-08
Dettol-3	6.44E-09	2.73E-09	6.23E-08	2.34 E-10	7.15 E-08
Kumarika-1	7.47E-09	1.04E-08	4.33E-06	1.51 E-10	4.33E-06
Kumarika-2	7.67E-09	1.01E-08	4.23E-06	1.34 E-10	4.25E-06
Kumarika-3	7.61E-09	1.02E-08	4.27E-06	1.51 E-10	4.29E-06
Himalaya-1	1.29E-08	9.50E-09	5.73E-06	1.00 E-10	5.75E-06
Himalaya-2	1.29E-08	9.50E-09	5.77E-06	1.00 E-10	5.79E-06
Himalaya-3	1.28E-08	9.77E-09	5.80E-06	1.00 E-10	5.82E-06
Margo-1	5.67E-09	1.48E-09	1.17E-07	1.51 E-10	1.24E -07
Margo-2	5.47E-09	1.33E-09	1.33E-07	1.51 E-10	1.40E -07
Margo-3	5.39E-09	1.64E-09	1.40E-07	1.67 E-10	1.47E -07
Sandalina-1	1.25E-08	4.12E-09	ND	3.01 E-10	1.66E-08
Sandalina-2	1.24E-08	4.30E-09	ND	2.84 E-10	1.67E-08
Sandalina-3	1.27E-08	4.37E-09	ND	2.84 E-10	1.71E-08
Neem-1	7.47E-09	9.90E-09	ND	2.17 E-10	1.74E-08
Neem-2	7.22E-09	9.50E-09	ND	2.17 E-10	1.67E-08
Neem-3	7.67E-09	1.01E-08	ND	2.17 E-10	1.78E-08
Cinthol-1	7.08E-09	5.00E-09	ND	2.34 E-10	1.21E-08

Cinthol-2	6.97E-09	4.83E-09	ND	2.17 E-10	1.18E-08
Cinthol-3	7.03E-09	4.77E-09	ND	1.84 E-10	1.18E-08
Keya-1	1.16E-08	1.01E-09	ND	2.51 E-10	1.26E-08
Keya-2	1.01E-08	1.17E-09	ND	2.67 E-10	1.13E-08
Keya-3	1.14E-08	8.57E-10	ND	2.67 E-10	1.23E-08

Table 8. Carcinogenic Risk of Chromium for dermal exposure pathways for soapsamples

Sample ID	SF for Cr	Cancer Risk (CR)
Dove-1	2×10^1	2.62E-08
Dove-2		2.62 E-08
Dove-3		2.66 E-08
Godrej-1		1.45 E-08
Godrej-2		1.50 E-08
Godrej-3		1.45 E-08
Meril-1		1.26 E-08
Meril-2		1.22 E-08
Meril-3		1.12 E-08
Savlon-1		9.82 E-09
Savlon-2		1.03 E-08
Savlon-3		1.03 E-08
Dettol-1		4.22 E-09
Dettol-2		3.28 E-09
Dettol-3		3.74 E-09
Kumarika-1		2.60 E-07
Kumarika-2		2.54 E-07
Kumarika-3		2.56 E-07
Himalaya-1		3.44 E-07
Himalaya-2		3.46 E-07
Himalaya-3		3.48 E-07
Margo-1		7.02 E-09
Margo-2		7.96 E-09
Margo-3		8.42 E-09
Sandalina-1		ND
Sandalina-2		ND
Sandalina-3		ND
Neem-1		ND
Neem-2		ND
Neem-3		ND
Cinthol-1		ND
Cinthol-2		ND
Cinthol-3		ND
Keya-1		ND
Keya-2		ND
Keya--3		ND

3.10. Carcinogenic Risk (CR)

The USEPA defines cancer risk (CR) as the increased likelihood of developing cancer during a lifetime due to exposure to a suspected cause. “Carcinogen” 36 Unavailability of dermal slope factor (SF) for Mn and BDL for Ni, Pb, and Cd. Table 8 shows the predicted carcinogenic risk (CR) for just Cr. According to [45], CR values ranging from 10-6 to 10-4 are considered acceptable. The study indicated that the cancer risk of Cr was far lower than the allowed level, indicating that there is no risk of Cr absorption via the skin from bar soaps for Bangladeshi residents. Our findings are consistent with other studies.

4. Conclusion

The soaps investigated were varied in their pH value. Keya soap has the highest pH (10.3), indicating it is more alkaline, while Dove is the least alkaline (7.3). pH levels in soap can affect skin sensitivity, and Keya may be less suitable for individuals with sensitive skin. Through this analysis, we were able to find the moisture content of different kinds of soaps. Neem soap has the highest moisture content at 15.11%, while Kumarika has the lowest at 8.40%. Neem soap might be more hydrating and suitable for individuals with dry skin, while Kumarika may be preferred by those who prefer a drier feel. Soaps with higher TFM content typically provide better moisturization and may be gentler on the skin. Dove soap has the lowest TFM at 60%, while Sandalina has the highest at 79.98%. Cinthol soap has the highest total alkali content at 2.64%, while Meril soap has the lowest at 1.45%. Cinthol may be harsher on the skin due to its higher alkali content, while Meril is milder. The soaps investigated varied in their metal concentrations. Among the trace metals, the highest concentration was found in Cr (7.45±0.01) and the lowest concentration was found in Mn (0.06±0.01), and the decreasing order of the metals was: Cr> Fe> Zn> Mn. It is important to note that all metals within the acceptable limit settled by WHO, USEPA, and EU except Cr.

The concentration of Cr is high in Kumarika and Himalaya soap samples. Elevated chromium levels may be a concern, as excessive exposure to chromium can have adverse effects on skin health. Further investigation is needed to determine the source and potential health implications. Long-term use of these soaps can cause Pulmonary disorders, nephritis, anuria and extensive lesions in the kidney. [19]

However, we could not compare the Fe value with this standard guideline because it does not have any stipulated value. Moreover, we have checked the human health risk assessment for dermal exposure to beauty soaps. For the first time, we observed the dermal exposure of beauty soaps studied in our study, and we found no possible non-carcinogenic or carcinogenic risks. In summary, the choice of soap depends on individual skin type and preferences. Neem and Sandalina soaps have high moisture and TFM content, which can be beneficial for those with dry skin. Meril Soap has a low alkali content, making it a milder option. Dove soap, despite having lower pH and TFM, may be suitable for those with sensitive skin. However, it is important to investigate the source of elevated chromium levels in Kumarika and Himalaya soaps to ensure consumer safety. In order to address safety concerns about humans exposed to trace metal contamination, intensive monitoring and mitigating methods might be employed.

References

[1] G. Baltas, and P. C. Argouslidis, "Consumer Characteristics and Demand for Store Brands," *International Journal of Retail & Distribution Management*, vol. 35, no. 5, pp. 325-341, 2007. [CrossRef] [Google Scholar] [Publisher Link]

[2] Aisyah Fitri Wahyulistiani et al., *"Workload Analysis to Determine the Number of Labor in Soap Production Using the Full Time Equivalent Method: A Case Study of PT. XY," Journal of Industrial Engineering Management, vol. 7, no. 3, pp. 232-237, 2022.* [CrossRef] [Google Scholar] [Publisher Link]

[3] N.O. Sawyerr, P.A. Danquah, and A. Benson, "The Effect of Locally Prepared Soaps With Different Oils on the Colour and Dimensional Stability of an African Print Fabric," *African Journal of Applied Research*, vol. 3, no. 1, pp. 38-44, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[4] Aulia Ryanda, Ismail Ibrahim, and Ida Adhayanti, "Level of Knowledge and Attitude of Senior High School 1 Sidrap Teenagers Regarding the Selection and Usage of Facial Whitening Cream Cosmetics," *Journal of Health and Nutrition Research*, vol. 2, no. 2, pp. 97-101, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[5] K.J. Betsy et al., "Determination of Alkali Content & Total Fatty Matter in Cleansing Agents," *Asian Journal of Science and Applied Technology*, vol. 2, no. 1, pp. 8-12, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[6] B.S. Bahl, and Arun Bahl, *Advanced Organic Chemistry*, 2nd ed., S. Chand & Company, pp. 1-1336, 1983. [Google Scholar] [Publisher Link]

[7] H.H. Uhlig, and F.C. Duemmling, "An Investigation of Free Alkali Determinations in Soap," *Oil and Soap*, vol. 13, pp. 307-314, 1936. [CrossRef] [Google Scholar] [Publisher Link]

[8] Julius Lewkowitsch, *Chemical Technology and Analysis of Oils, Fats, and Waxes*, Macmillan and Company, vol. 3, 1921. [Google Scholar] [Publisher Link]

[9] Analysis of Soaps - Determination of Total Alkali Content and Total Fatty Matter Content, International Standard, pp. 1-6, 1975. [Online]. Available: https://cdn.standards.iteh.ai/samples/4880/fd527083c01f4b0d91d42995107f6a90/ISO-685-1975.pdf

[10] David J. Anneken et al., "Fatty Acids," *Ullmann's Encyclopedia of Industrial Chemistry*, 2006. [CrossRef] [Publisher Link]

[11] S. Arasaretnam, and K. Venujah, "Preparation of Soaps by Using Different Oil and Analyze their Properties," *Natural Products Chemistry & Research*, vol. 7, no. 1, pp. 1-4, 2019. [Google Scholar] [Publisher Link]

[12] I. Ahmed, Palm Oil Research Institute of Malaysia (PORIM), Selangor, Malaysia, pp. 1-17, 1984. [Google Scholar]

[13] Sarfaraz Ahmed Mahesar, Razia Chohan, and Syed Tufail Hussain Sherazi, "Evaluation of Physico-Chemical Properties in Selected Branded Soaps," *Pakistan Journal of Analytical & Environmental Chemistry*, vol. 20, no. 2, pp. 177-183, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[14] Benjamin Makimilua Tiimub, and Mercy Ananga Dzifa Afua, "Determination of Selected Heavy Metals and Iron Concentration in Two common Fish Species in Densu River at Weija District in Grater Accra Region of Ghana," *American International Journal of Biology*, vol. 1, no. 1, pp. 29-34, 2013. [Google Scholar]
[15] Umit Divrikli et al., "Trace Heavy Metal Contents of Some Spices and Herbal Plants from Western Anatolia, Turkey," *International Journal of Food Science & Technology*, vol. 41, no. 6, pp. 712-716, 2006. [CrossRef] [Google Scholar] [Publisher Link]
[16] Ufuk Çelik, and Jörg Oehlenschläger, "High Contents of Cadmium, Lead, Zinc and Copper in Popular Fishery Products Sold in Turkish Supermarkets," *Food Control*, vol. 18, no. 3, pp. 258-261, 2007. [CrossRef] [Google Scholar] [Publisher Link]
[17] J.G. Ayenimo et al., "Heavy Metal Fractionation in Roof Run off in Ile-Ife, Nigeria," *International Journal of Environmental Science & Technology*, vol. 3, pp. 221-227, 2006. [CrossRef] [Google Scholar] [Publisher Link]
[18] F. Islam et al., "Heavy Metals in Water, Sediment and Some Fishes of Karnofuly River, Bangladesh," *Environmental Biotech Journals, Pollution Research*, vol. 32, no. 4, pp. 715-721, 2013. [Google Scholar] [Publisher Link]
[19] Kawser Ahmed et al., "Human Health Risks from Heavy Metals in Fish of Buriganga River, Bangladesh," *SpringerPlus*, vol. 5, pp. 1-12, 2016. [CrossRef] [Google Scholar] [Publisher Link]
[20] Md. Khalid Hasan et al., "Trace Metals Contamination in Riverine Captured Fish and Prawn of Bangladesh and Associated Health Risk," *Exposure and Health*, vol. 13, pp. 237-251, 2021. [CrossRef] [Google Scholar] [Publisher Link]
[21] O.P. Sobukola et al., "Heavy Metal Levels of Some Fruits and Leafy Vegetables from Selected Markets in Lagos, Nigeria," *African Journal of Food Science*, vol. 4, no. 2, pp. 389-393, 2010. [Google Scholar] [Publisher Link]
[22] Hao Liu et al., "Heavy Metal Contamination in Soil Alongside Mountain Railway in Sichuan, China," *Environmental Monitoring and Assessment*, vol. 152, pp. 25-33, 2009. [CrossRef] [Google Scholar] [Publisher Link]
[23] J.G. Ayenimo et al., "Heavy Metal Exposure from Personal Care Products," *Bulletin of Environmental Contamination and Toxicology*, vol. 84, pp. 8-14, 2010. [CrossRef] [Google Scholar] [Publisher Link]
[24] S.A. El-Safty et al., "Nanosensor Design Packages: A Smart and Compact Development for Metal Ions Sensing Responses," *Advanced Functional Materials*, vol. 17, no. 18, pp. 3731-3745, 2007. [CrossRef] [Google Scholar] [Publisher Link]
[25] Baolin Wu et al., "Comparison of Statistical Methods for Classification of Ovarian Cancer Using Mass Spectrometry Data," *Bioinformatics*, vol. 19, no. 13, pp. 1636-1643, 2003. [CrossRef] [Google Scholar] [Publisher Link]
[26] Elisabeth Bangha et al., "Daytime Serum Levels of Melatonin after Topical Application onto the Human Skin," *Skin Pharmacology and Applied Skin Physiology*, vol. 10, no. 5-6, pp. 298-302, 1997. [CrossRef] [Google Scholar] [Publisher Link]
[27] P. Olmedo et al., "Validation of a Method to Quantify Chromium, Cadmium, Manganese, Nickel and Lead in Human Whole Blood, Urine, Saliva and Hair Samples by Electrothermal Atomic Absorption Spectrometry," *Analytica Chimica Acta*, vol. 659, no. 1-2, pp. 60-67, 2010. [CrossRef] [Google Scholar] [Publisher Link]
[28] Ashrafy Habib et al., "Study on the Physicochemical Properties of Some Commercial Soaps Available in Bangladeshi Market," *International Journal of Advanced Research in Chemical Science*, vol. 3, no. 6, pp. 9-12, 2016. [CrossRef] [Google Scholar] [Publisher Link]
[29] Sandra L. Decker, "Two-Thirds of Primary Care Physicians Accepted New Medicaid Patients in 2011–12: A Baseline to Measure Future Acceptance Rates," *Health Affairs*, vol. 32, no. 7, pp. 1183-1187, 2013. [CrossRef] [Google Scholar] [Publisher Link]
[30] Eunyoung Kim, John C. Little, and Nancy Chiu, "Estimating Exposure to Chemical Contaminants in Drinking Water," *Environmental Science & Technology*, vol. 38, no. 6, pp. 1799-1806, 2004. [CrossRef] [Google Scholar] [Publisher Link]
[31] Risk Assessment Guidance for Superfund Human Health Evaluation Manual (Part A), U.S. Environmental Protection Agency, vol. 1, pp. 1-291, 1989. [Online]. Available: https://www.epa.gov/sites/default/files/2015-09/documents/rags_a.pdf
[32] Risk Assessment, United States Environmental Protection Agency. [Online]. Available: https://www.epa.gov/risk.
[33] A.K.M. Atique Ullah et al., "Dietary Intake of Heavy Metals from Eight Highly Consumed Species of Cultured Fish and Possible Human Health Risk Implications in Bangladesh," *Toxicology Reports*, vol. 4, pp. 574-579, 2017. [CrossRef] [Google Scholar] [Publisher Link]
[34] K. Guerra, *Exposure Factors Handbook*, Washington DC: USEPA, 2010. [Google Scholar]
[35] Szu-Chich Chen, and Chung-Min Liao, "Health Risk Assessment on Human Exposed to Environmental Polycyclic Aromatic Hydrocarbons Pollution Sources," *Science of the Total Environment*, vol. 366, no. 1, pp. 112-123, 2006. [CrossRef] [Google Scholar] [Publisher Link]
[36] S. Obiri et al., "Cancer Health Risk Assessment of Exposure to Arsenic by Workers of AngloGold Ashanti-Obuasi Gold Mine," *Bulletin of Environmental Contamination and Toxicology*, vol. 76, pp. 195-201, 2006. [CrossRef] [Google Scholar] [Publisher Link]
[37] Lourdes Baranda et al., "Correlation between pH and Irritant Effect of Cleansers Marketed for Dry Skin," *International Journal of Dermatology*, vol. 41, no. 8, pp. 494-499, 2002. [CrossRef] [Google Scholar] [Publisher Link]
[38] O. Idoko et al., "Quality Assessment on Some Soaps Sold in Nigeria," *Nigerian Journal of Technology*, vol. 37, no. 4, pp. 1137-1140, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[39] O.E. Popoola et al., "Heavy Metal Content and Antimicrobial Activities of Some Naturally Occurring Facial Cosmetics in Nigeria," *IFE Journal of Science*, vol. 15, no. 3, pp. 637-644, 2016. [Google Scholar] [Publisher Link]

[40] Ramakant Sahu, Poornima Saxena, and Sapna Johnson, "Heavy Metal in Cosmetics," *Centre for Science and Environment*, vol. 45, pp. 3-28, 2014. [Google Scholar] [Publisher Link]

[41] Mohammad MN Authman et al., "Use of Fish as Bio-indicator of the Effects of Heavy Metals Pollution," *Journal of Aquaculture Research & Development*, vol. 6, no. 4, pp. 1-13, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[42] Pinaki Panigrahi et al., "A Randomized Synbiotic Trial to Prevent Sepsis among Infants in Rural India," *Nature*, vol. 548, no. 7668, pp. 407-412, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[43] Kumar Sukender et al., "AAS Estimation of Heavy Metals and Trace Elements in Indian Herbal Cosmetic Preparations," *Research Journal of Chemical Sciences*, vol. 2, no. 3, pp. 46-51, 2012. [Google Scholar] [Publisher Link]

[44] M.A. Umar, and H. Caleb, "Analysis of Metals in Some Cosmetics Products in FCT-Abuja, Nigeria," *International Journal of Research in Cosmetic Science*, vol. 3, no. 2, pp. 14-18, 2013. [Google Scholar]

[45] A.K.M. Atique Ullah et al., "Evaluation of Possible Human Health Risk of Heavy Metals from the Consumption of Two Marine Fish Species Tenualosa Ilisha and Dorosoma Cepedianum," *Biological Trace Element Research*, vol. 191, pp. 485-494, 2019. [CrossRef] [Google Scholar] [Publisher Link]