

MINERAL CONTENT ANALYSIS OF CHANDONPOKPI VILLAGE CLAYS USING SEM-EDXS: IMPLICATIONS FOR DERMA- COSMETIC APPLICATIONS

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Article Received on 17 Feb. 2026,
Article Revised on 06 March 2026,
Article Published on 16 March 2026,

<https://doi.org/10.5281/zenodo.19046322>

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How to cite this Article: Laishram Premjit Singh^{1*}, Sagolshem Lokhol Singh², M. Premchand Singh³, Y. Sexona Singh⁴. (2026). Mineral Content Analysis of Chandonpokpi Village Clays Using Sem-Edxs: Implications For Derma-Cosmetic Applications. World Journal of Pharmaceutical Research, 15(6), 1011-1025. This work is licensed under Creative Commons Attribution 4.0 International license.

ABSTRACT

Soil clays are layered materials with diverse particle properties that can be incorporated into various applications. Samples from different layers of Chandonpokpi S/T village in Tengenoupal District, Manipur (hilly area), were analyzed using Energy Dispersive X-Ray Spectroscopy (EDXS) after moisture removal by heating, followed by Scanning Electron Microscopy (SEM) to determine their chemical composition. An elemental sum spectrum was also obtained to reveal the dominant and trace elements present in the soil samples. Differences in chemical composition, texture, particle size, and color were observed among the samples. The clays exhibited a pH range of 4.5 to 6.9. Particular attention is given to the pharmacological functions of these clays and their applications in pelotherapy, wound healing, regenerative medicine, antimicrobial treatments, and dermocosmetics.

KEYWORDS: Energy Dispersive X-Ray Spectroscopy

(EDXS), Scanning Electron Microscope (SEM).

INTRODUCTION

Soil forms the intermediate zone between Earth's atmosphere, lithosphere, and rock cover. It can be described as the earth's uppermost weathered crust layer, where a mixture of living organisms and the products of their decay is present. In Manipur, Inceptisols are the dominant soil type, followed by Ultisols, Entisols, and Alfisols. Clay from soil has been used for various purposes since prehistoric times.^[1] The soil typically has a clayey texture, ranging from grey-brown to dark brown sandy loam. Different types of clays contain various elements: common clays contain Al^{3+} and Mg^{2+} ; yellow clay contains Fe^{3+} ; red clays contain Mn^{3+} , Fe^{3+} , Co^{3+} , and Ti^{4+} ; green clay contains Fe^{2+} , Fe^{3+} , Cr^{3+} , and Ni^{2+} .

Clay can also be classified depending on the way that the tetrahedral and octahedral sheets are packed into layers. The major groups of clay minerals present in the soil environment include layer and chain silicates, sesquioxides, and other inorganic minerals. The hill soils are rich in organic carbon (1-3%) in the topsoil, but poor in phosphorus and potassium. Geologists and soil scientists, usually consider the size of the clay particle to be $2\mu m$. Sedimentologists use a particle size of $4\mu m$, and colloid chemists use a $1\mu m$ clay particle size². The clay study depends on the particle size.

Among all the clays, some are white in colour, which is known as chandon in Manipuri. Manipuri meiteis, in a rather extended form of the philosophical and religious beliefs. Chandon is made from natural soil in Chandonpokpi village, Chandel District, Manipur. Manipuris in the medieval period undertook the custom of applying chandon, more specifically on the forehead, in all religious and ritual functions. Naturally, the surrounding area of Chandonpokpi villagers is making the chandon with simple processes. The clay samples are ground into dust and filtered to remove other unwanted waste materials. After that, it was mixed with hot water to form a lump of paste. It can be mixed with a good smell to get a good-smelling chandon. Then cool it, but not a dry condition. For this, after the lump paste, we can cut any desired shape and size. The final shape of the chandon at this villages is brought by vehicle to the different markets and the main market at Imphal, and sold.

Clays have different influences on the properties as clay minerals modify the construction materials.^[3,4] The mechanism of geopolymers made from clay is not well understood^[5] Geopolymers are used as construction materials^[6] Clay have for use in construction, paints, rubbers, cosmetics, plastics, and pharmaceutical industry.^[7,8] Some clay minerals are used in shampoos, soaps, and toothpaste as abrasives, for their properties of impurity absorption^[9]

Cosmetics depend on their chemical and mineralogical compositions. Clays are rich in iron, silicon, magnesium, titanium, and potassium. They present antibacterial, antiseptic, and regenerative efficacy, contribute to cell renewal, adsorb impurities, and activate microcirculation. It is used for numerous cosmetic products. Iron is an antiseptic and catalyzes cell renewal. Silicon helps to regenerate and hydrate the skin, zinc and magnesium are invigorating, potassium acts on circulation and tissue invigorating, and titanium is used as a UV filter.^[10,11] Clays are mostly used in face masks due to their high adsorbency levels on the skin surface, such as greases, toxins, bacteria, and viruses. They are also used for cleansing and lifting effect.^[12]

The art of applying Chandon, as observed by Manipur, is rather an extension of the philosophical and religious belief, which is made from natural soil in Chandonpokpi village, Chandel District, Manipur. Manipuris in the medieval period undertook the custom of applying Chandon, more specifically on the forehead, in all religious functions. The determination of the mineral contents in different clay samples is performed using Electron Dispersive X-Ray Spectroscopy (EDXS) and Scanning Electron Microscope (SEM).

MATERIALS AND METHODS

The soil samples were collected from the Chandonpokpi village (hilly area), specifically from the 1st layer (surface of the soil), the 2nd layer (3 ft. depth), and the 3rd layer (5 ft. depth). All the samples were stored in different coloured polythene bags. Clay samples of the first layer, i.e. surface layer only was taken for instrumentation, leaving the rest of the samples for future analyses.

Chandonpokpi S/T village is located in the Tengnoupal District in Manipur, India. The District has a geographic area of 1,213sq.km. The Tengnoupal District (24° 19'41" N 93° 59'10"E/24.3 28° N 93°986^O E) is situated in the southern part of Manipur, bounded by Myanmar on south west and Thoubal District on the north. The region experiences a subtropical climate, receiving 2000mm of annual rainfall and temperatures ranging from 10 °C to 38 °C.

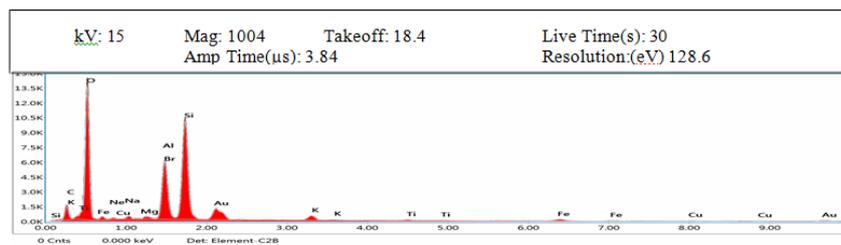
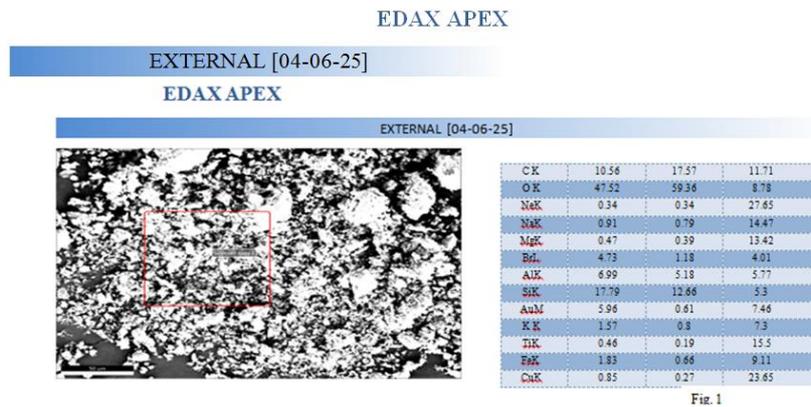
SAMPLE PREPARATION

Three samples were collected from the Chandonpokpi village (hilly area) as 1st layer (surface area), 2nd layer (about 3 ft. depth), and 3rd layer (about 5 ft. depth), etc., using the gloves in order to avoid any kind of contamination and thoroughly homogenized by a mortar and

pestle. The fine particle size of clay samples of the first layer i.e. surface layer only was placed in an oven at 70 °C for 24 hours, and packed in small plastic containers for laboratory analysis.

RESULTS AND DISCUSSIONS

This clay sample shows that the back scattered grains consisting of smooth grains as well as powdered aggregates and Oxygen, Silicon dominated elements.



Smart Quant Results

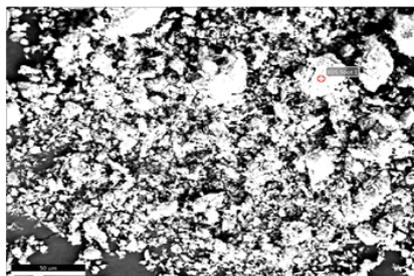
Element Weight % Atomic % Error %

EDAXAPEX

EXTERNAL [04-06-25]

Author: Apex User
Creation: 6/4/2025 12:14:01 PM
SampleName: MANIPUR

Area 1



Smart Quant Results

Element	Weight %	Atomic %	Error %
O K	51.67	69.9	8.15
NaK	0.39	0.42	20.58
NaK	1.18	1.11	13.15
MgK	0.54	0.48	10.5
BdL	5.15	1.4	3.73
AlK	10.89	8.74	5.44
SiK	19.99	15.4	5.56
AuM	6.34	0.7	5.75
K K	2.31	1.28	5.43
FeK	0.99	0.39	13.3
CuK	0.54	0.18	30.26

Fig. 3

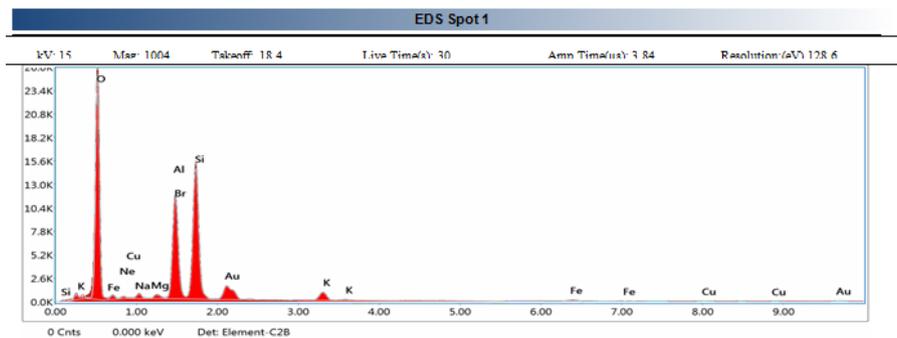
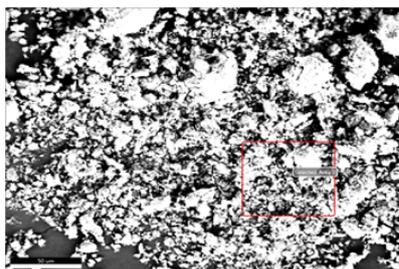


Fig. 4

EDAX APEX

EXTERNAL [04-06-25]

Author: Apex User
 Creation: 6/4/2025 12:14:38 PM
 Sample Name: MANIPUR

Area 1**Smart Quant Results**

Element	Weight %	Atomic %	Error
C K	6.6	11.53	12.59
O K	47.07	61.71	8.7
Na K	0.29	0.3	31.25
Na K	0.95	0.87	14.98
Mg K	0.51	0.44	12.21
Br L	5.37	1.41	3.8
Al K	7.12	5.53	5.9
Si K	20.5	15.31	5.39
Au M	6.34	0.67	6.78
K K	1.73	0.93	7.68
Ti K	0.47	0.21	15.86
Fe K	2.1	0.79	8.67
Cu K	0.97	0.32	26.78

Fig. 5

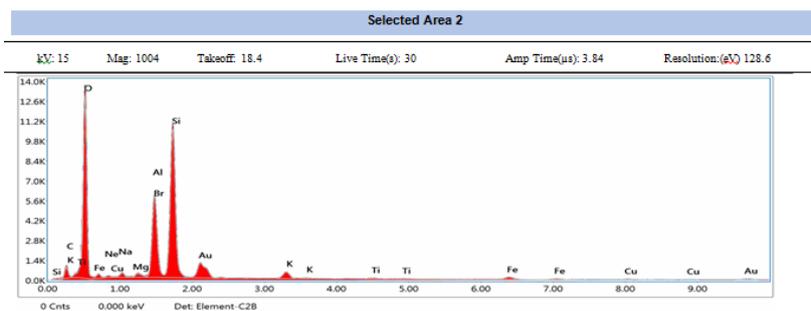


Fig. 6

EDAX APEX

EXTERNAL [04-06-25]

Author: Apex User
 Creation: 6/4/2025 12:15:14 PM
 Sample Name: MANIPUR

Area 1

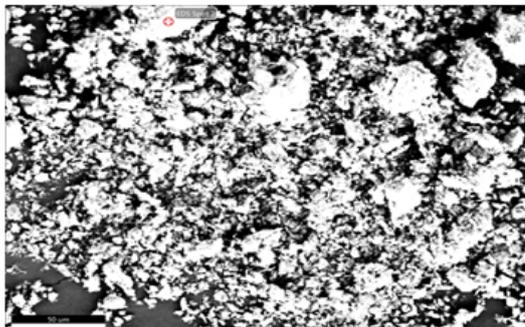


Fig. 7

Smart Quant Results

Element	Weight %	Atomic %	Error %
O K	46.09	64.67	8.53
NaK	0.94	0.92	13.59
MgK	0.55	0.51	10.56
BrL	6.64	1.86	3.09
AlK	6.96	5.79	5.56
SiK	29.81	23.83	5.22
AuM	5.24	0.6	7.17
K K	1.97	1.13	7.15
FeK	1.02	0.41	14.16
CuK	0.78	0.27	29.66

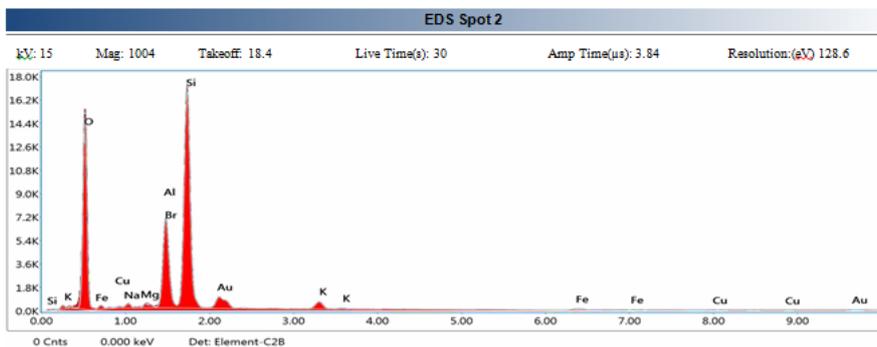


Fig. 8

EDAX APEX

EXTERNAL [04-06-25]

Author: Apex User
 Creation: 6/4/2025 12:20:45 PM
 Sample Name: MANIPUR

Area 2

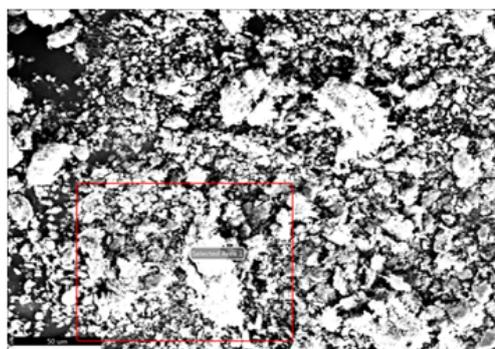


Fig. 9

Smart Quant Results

Element	Weight %	Atomic %	Error %
C K	12.97	21.29	11.16
O K	46.18	56.88	8.93
NaK	0.19	0.19	41.97
NaK	0.82	0.7	14.76
MgK	0.42	0.34	13.72
BrL	5.04	1.24	3.93
AlK	6.4	4.67	5.87
SiK	17.2	12.07	5.27
AuM	5.61	0.56	7.43
K K	1.66	0.84	6.7
TK	0.41	0.17	20.52
FeK	2.09	0.74	9.56
CoK	0.23	0.08	38.59
CuK	0.78	0.24	34.84

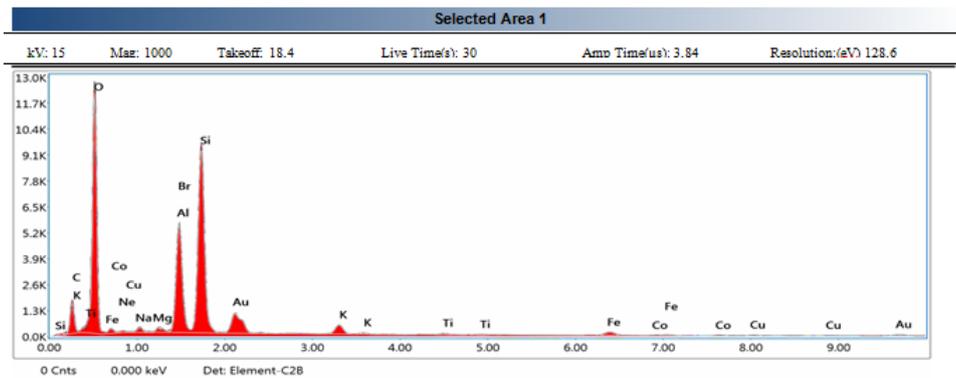


Fig. 10 EDXS – SEM Mapping of 1st Layer

EDAX APEX

EXTERNAL [04-06-25]

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 Creation: 6/4/2025 12:21:21 PM
 Sample Name: MANIPUR

Area 2

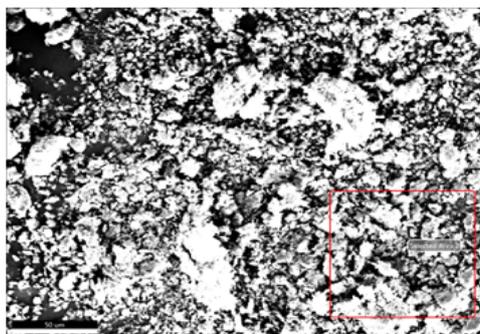


Fig. 11

Smart Quant Results

Element	Weight %	Atomic %	Error %
CK	9.28	16.03	12.16
OK	44.74	58.01	8.92
NeK	0.3	0.31	29.37
NaK	0.95	0.85	14.57
MgK	0.5	0.43	12.33
BrL	5.73	1.49	3.73
AlK	6.64	5.1	5.93
SiK	19.99	14.76	5.37
AuM	6.29	0.66	7.07
KK	1.82	0.97	7.06
TiK	0.53	0.23	17.75
FeK	2.36	0.88	8.56
CuK	0.88	0.29	35.42

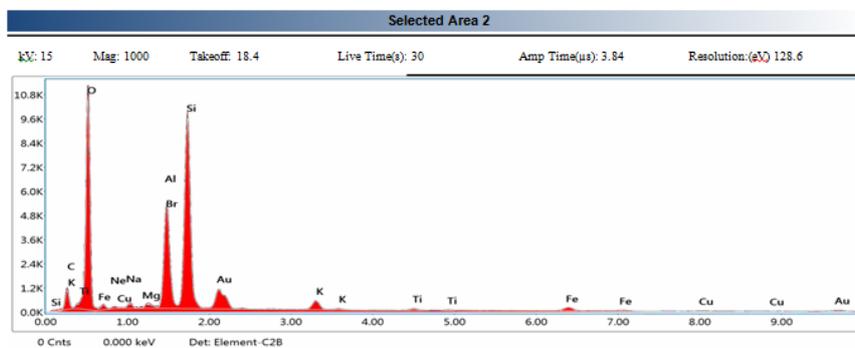


Fig. 12

EDAX APEX

EXTERNAL [04-06-25]

Author: Apex User
 Creation: 6/4/2025 12:21:56 PM
 Sample Name: MANIPUR

Area 2

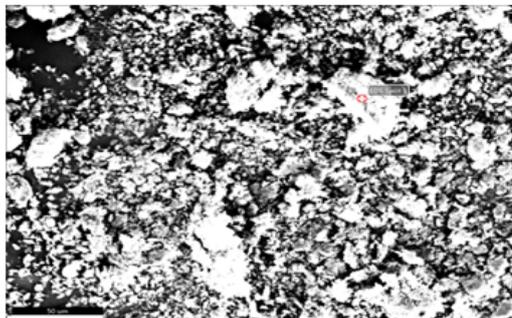


Fig. 13

Smart Quant Results

Element	Weight %	Atomic %	Error %
O K	34.16	55.03	9.1
NaK	1.02	1.15	13.58
MgK	0.62	0.66	12.11
BdL	7.9	2.55	3.75
AlK	13.84	13.22	5.6
SiK	23.25	21.34	6.15
AuM	10.2	1.33	4.96
K K	3.16	2.08	6.68
FeK	4.77	2.2	6.24
CuK	1.07	0.44	30.27

EDS Spot 1

kV: 15 Mag: 1000 Takeoff: 18.4 Live Time(s): 30 Amp Time(μs): 3.84 Resolution:(eV) 128.6

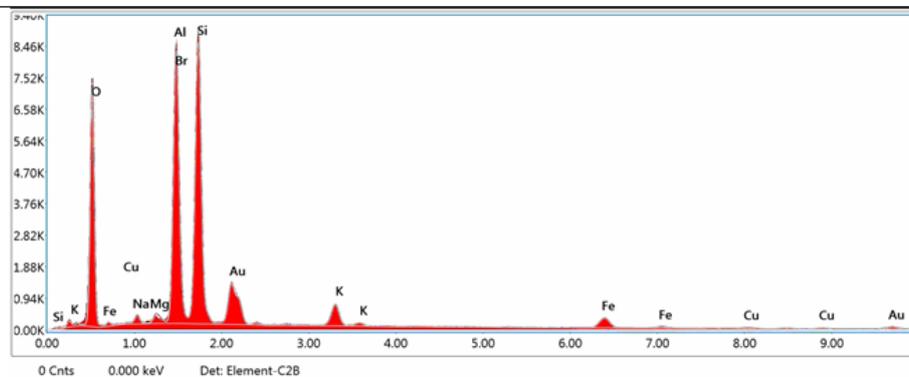


Fig. 14

EDAX APEX

EXTERNAL [04-06-25]

Author: Apex User
 Creation: 6/4/2025 12:22:35 PM
 Sample Name: MANIPUR

Area 2

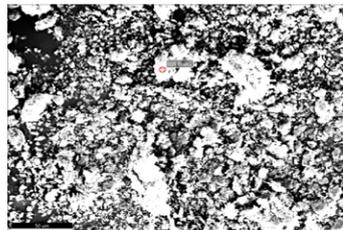


Fig. 15

Smart Quant Results

Element	Weight %	Atomic %	Err
O K	40.23	60.94	8.76
MgK	0.67	0.66	10.72
BdL	9.24	2.5	3.45
AlK	9.36	8.4	3.81
SiK	23.45	21.09	5.88
PK	2.86	2.33	6.72
AuM	5.57	0.69	7.21
K K	1.75	1.09	8.39
BdL	1.32	0.23	29.84
CaL	1.26	0.22	33.4
NdL	1.22	0.21	41.72
PbK	1.18	0.51	19.52
CuK	0.86	0.33	36.13

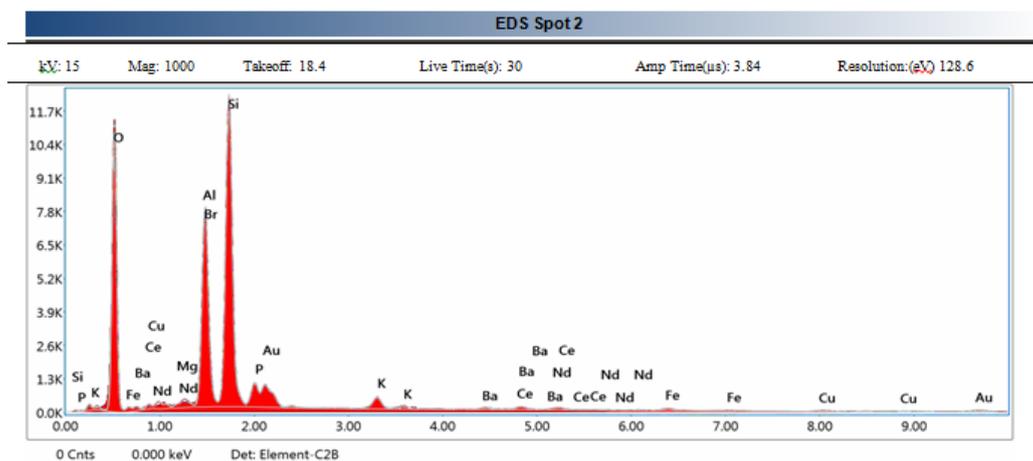


Fig. 16

Area 1

Element	Weight %	Atomic %	Error %
CK	10.56	17.15	11.71
	66	11.53	12.59
OK	47.52	59.36	8.78
	51.67	69.9	8.15
	47.07	61.71	8.7
	46.09	64.67	8.53
NeK	0.34	0.34	27.65
	0.39	0.42	20.58
	0.29	0.3	31.25
NaK	0.91	0.79	14.47
	1.18	1.11	13.15
	0.95	0.87	14.98
	0.94	0.92	13.59
MgK	0.47	0.39	13.42
	0.54	0.48	10.5
	0.51	0.44	12.21
	0.55	0.51	10.56
BrL	4.73	1.18	4.01
	5.15	1.4	3.73
	5.37	1.41	3.8
	6.64	1.86	3.09
AlK	6.99	5.18	5.77
	10.89	8.74	5.44
	7.12	5.53	5.9
	6.96	5.79	5.56
SiK	17.79	12.66	5.3
	19.99	15.4	5.56
	20.5	15.31	5.39
	29.81	23.83	5.22
AuM	5.96	0.61	7.46

	6.34	0.7	5.75
	6.34	0.67	6.78
	5.24	0.6	7.17
KK	1.57	0.8	7.3
	2.31	1.28	5.43
	1.73	0.93	7.68
	1.97	1.13	7.15
TiK	0.47	0.19	15.5
	0.47	0.21	15.86
FeK	1.83	0.66	9.11
	0.99	0.39	13.3
	2.1	0.79	8.67
	1.02	0.41	14.16
CuK	0.85	0.27	23.65
	0.54	0.18	30.26
	0.97	0.32	26.78
	0.78	0.27	29.66
	0.78	0.24	34.84

Area 2

Element	Weight %	Atomic %	Error %
CK	12.97	21.29	11.16
	9.28	16.03	12.16
OK	46.18	56.88	8.93
	44.74	58.01	8.92
	34.16	55.03	9.1
	40.23	60.94	8.76
NeK	0.94	0.92	13.59
	0.19	0.19	41.97
	0.3	0.31	29.37
NaK	0.82	0.7	14.76
	0.95	0.85	14.57
	1.02	1.15	13.58
MgK	0.42	0.34	13.72
	0.5	0.43	12.33
	0.62	0.66	12.11
	0.67	0.66	10.72
BrL	5.04	1.24	3.93
	5.73	1.49	3.73
	7.9	2.55	3.75
	8.24	2.5	3.45
AlK	6.4	4.67	5.87
	6.64	5.1	5.93
	13.84	13.22	5.6
	9.36	8.4	5.81
SiK	17.2	12.07	5.27
	19.99	14.76	5.37
	23.25	21.34	6.15

	25.48	21.99	5.86
AuM	5.61	0.56	7.43
	6.29	0.66	7.07
	10.2	1.33	4.96
	5.57	0.69	7.21
KK	1.66	0.84	6.7
	1.82	0.97	7.06
	3.16	2.08	6.68
	1.75	1.09	8.39
TiK	0.41	0.17	20.52
	0.53	0.23	17.75
FeK	2.09	0.74	9.56
	2.36	0.88	8.56
	4.77	2.2	6.24
	1.18	0.51	19.52
CuK	0.88	0.29	35.42
	1.07	0.44	30.27
	0.86	0.33	36.13
CoK	0.23	0.08	38.59

Area 1

The above data shows that sample 1,2,3 of area 1.Chandonpokpi is an oxygen rich silicon with other elements like Aluminium, Bromine, Gold, Potassium, Magnesium, Iron, Copper etc. in fig.(1,2,3,4,5,6); Sample no.4, the clay shows that silicon dominated with oxygen containing other elements like Aluminium, Bromine, Gold, Potassium, Magnesium, Iron, Sodium, Copper etc. in fig.(7,8).

Area 2

The EDXS- SEM data area 2. The clay samples 1 and 2 are oxygen dominated silicon with other elements like Aluminium, Bromine, Potassium, Gold, Magnesium, Iron, Sodium, Copper, etc. in fig. (9,10,11,12); Sample no.3. The clay shows that silicon dominated Aluminium, Bromine, Potassium, Gold, Magnesium, Iron, Sodium, Copper etc. in fig.(13,14); Sample no.4, silicon dominated with oxygen containing other elements like Aluminium, Bromine, Potassium, Gold, Phosphorus, Iron, Neon etc. in fig. (15,16). The Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDXS) analysis of samples provide details on the elemental composition including the weight percentage, atomic percentage, and error margins for the elements of carbon, oxygen, sodium, magnesium, aluminum, silicon, potassium, titanium, iron and copper with the bottom graph showing the spectral peaks corresponding to these elements. In derma cosmetics this analysis indicates the elemental composition and surface distribution of inorganic ingredients.

These different elements and other minerals found in the clay sample can offer various benefits in cosmetics.

1. Silicon (Si) is often used in skincare products for its ability to strengthen the skin's connective tissues, improve elasticity, and promote a smooth texture thus used in derma cosmetics for oil control, mattifying effect, smooth skin feel, and texture improvement
2. Aluminium (Al) in certain forms, aluminosilicates can act as an absorbent and astringent, helping to control oil and refine pores.
3. Magnesium (Mg) is known for its calming and soothing properties, it can help reduce inflammation and support skin hydration.
4. Iron (Fe) often used for its antioxidant properties which can help protect the skin from environmental stressors and improve overall skin tone.
5. Copper (Cu) is known to aid in collagen production and skin regeneration, which can help with skin healing and reducing signs of aging.
6. Titanium (Ti) which is commonly used in sunscreens for its UV protective properties, helping to shield the skin from harmful rays even in small amounts

The clays containing these elements when used appropriately, can contribute to healthier and more radiant skin, the indications of these elements in derma cosmetics context is

1. Presence of inorganic fillers and pigments
 - Silicon (Si) & Oxygen (O)- in the form of Silica/Silicates is used for oil control, mattifying effect, smooth skin feel, and texture improvement.
 - Aluminium (Al) as alumino-silicates is often part of clays or coating agents that improve stability and spread ability.
 - Iron (Fe) as Iron oxides is common colour pigments in making foundations, BB creams, sunscreens, and tinted products.
2. UV-protective or functional mineral components
 - Titanium (Ti) even in small amounts is a physical UV filter widely used in sunscreens as Titanium dioxide.
 - Ti+Si+Al often indicate coated mineral UV filters, used to reduce irritation and improve photo stability.

3. Skin feel and formulation performance

- High O + Si content supports Sebum absorption, Blurring/soft-focus effects and improved wear and non-greasy finish.

4. Trace elements

- Na, K, Mg, Ca (minor levels) are typical of natural minerals/clays used in derma cosmetics.
- Br (Bromine) is usually a trace impurity
- Gold (Au) low percentage indicates gold nanoparticles used in luxury skin care for anti-aging and glow.

CONCLUSION

The SEM-EDXS analysis reveals a heterogeneous mineral rich morphology with a predominance of inorganic constituents, which is characteristic of derma cosmetic formulations designed for surface protection and functional performance. The elemental composition is dominated by oxygen and silicon, indicating the presence of silica or silicate - based minerals. These components are widely employed in derma cosmetics due to their oil absorbing capacity, mattifying effect, and ability to enhance tactile properties and formulation stability.

Aluminium detected in the samples is likely associated with aluminosilicate structures or clay derived minerals. Such materials are commonly incorporated into topical formulations in improve rheological behavior, film formation, and uniform distribution of active ingredients on the skin surface. The co-existence of Si and Al further supports the presence of layered or coated mineral systems, which are frequently used to improve skin compatibility and reduce irritation.

Iron and titanium were detected in minor concentrations, suggesting the presence of iron oxides and titanium dioxide, respectively. Iron oxides are extensively used as cosmetic pigments to impart colouration and tone correction in foundations and tinted derma cosmetic products. Titanium dioxide, even at low levels, plays a crucial role as a physical UV filter, contributing to photo-protection by reflecting and scattering ultraviolet radiation. The low atomic percentage of Ti suggests either a thin surface coating or dispersion within the formulation matrix rather than bulk mineral loading.

Trace elements such as sodium, potassium, magnesium, calcium, and copper, etc. were also observed, likely originating from natural mineral sources. Their low concentrations indicate no significant functional role but reflect the mineral origin of the formulation components. The detection of bromine as trace amount may also be attributed to residual processing agents or environmental contamination and does not contribute to derma-cosmetic functionality. Interestingly, the presence of gold indicate the incorporation of gold-based additives, which are increasingly used in premium derma-cosmetic formulations for their claimed anti-aging, anti-inflammatory, and skin radiance-enhancing properties. However, the possibility of gold arising from sample preparation or coating during SEM analysis cannot be excluded and warrants further confirmation using complementary analytical techniques.

The overall SEM-EDXS findings indicate that the clay layer is predominantly composed of inorganic mineral constituents that contribute to photo-protection, sebum control, colour enhancement, and surface smoothness. The elemental distribution supports the formulation's intended role as a protective and functional topical layer, reinforcing its suitability for formulation and use in advanced derma-cosmetic applications.

ACKNOWLEDGEMENT

The authors are grateful to the Principal, South East Manipur College, Komlathabi, Chandel District, Manipur, for providing laboratory facilities in the chemistry department of the college. The authors also acknowledge their gratitude to Dr. Sadananda Sharma and his staff of CIF, IIT Guwahati, for performing Energy Dispersive X-Ray Spectroscopy – Scanning Electron Microscope(EDXS-SEM) and providing the technical knowledge that made the research more effective. The authors also thank all the teaching and non-teaching staff of the South East Manipur College, Komlathabi, Manipur, for their cooperation.

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