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New Industrial Use of Egyptian White Sands from Wadi El-Dakhl Area, Eastern Desert, Egypt

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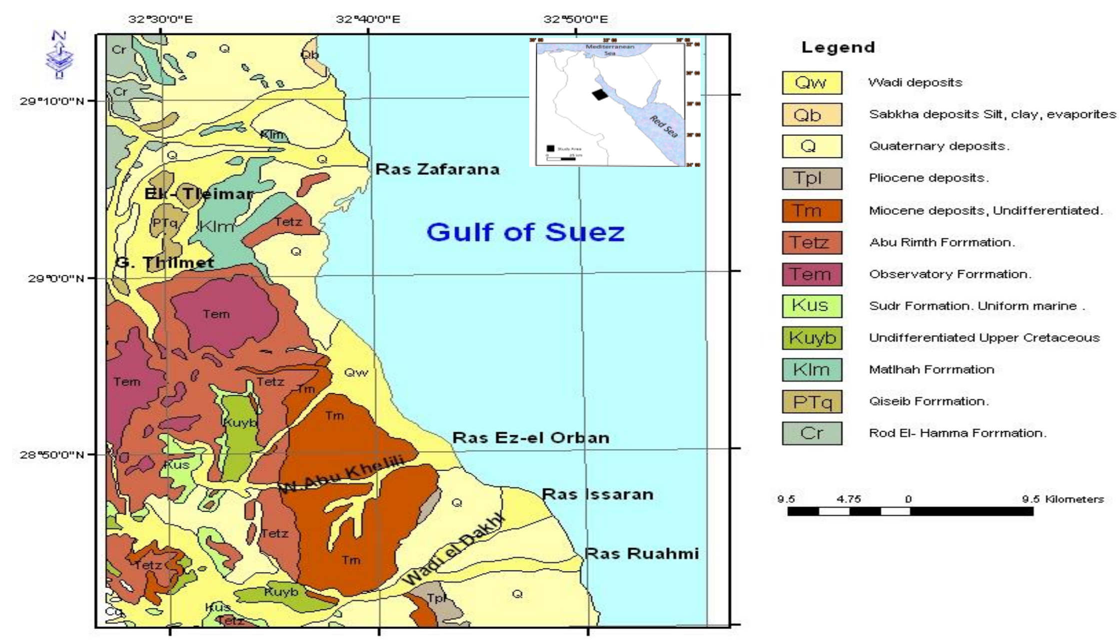
Abstract: New industrial use of white sands to produce anticorrosion and abrasion resistance coatings is the aim of this study. The white sands were collected from Early Cretaceous Malha Formation at Wadi El-Dakhl area, Eastern Desert, Egypt as a source of SiO_2. The changing of solid sands to a liquid compound passed through processes to obtain the special sodium silicate compound which reacts with galvanized steel surface and in another stage add a coat with appreciated thickness. Steel galvanized surface plates were prepared and immersed in a special sodium silicates solution for special conditions lead to get samples treated and coated with the solution exposed to testing. The obtained results showed that in additional to the corrosion protection of the hot deep galvanized surface, the treatment and coating of such surface by the solution suggested accepted offer as a protective coating especially in aggressive conditions.

Keywords: White sands, sodium Silicates, Anticorrosion, Wadi El-Dakhl and Egypt.

1- Introduction

Wadi El-Dakhl area is delineated by latitudes 28° 45' N. and longitude 32° 30' E. at Southern Galala in south Zaafrana area, west Gulf of Suez, Eastern Desert, Egypt **(Fig. 1).** The white sands at Wadi El-Dakhl are belonged to Malha Formation (Early Cretaceous age). Malha Formation was introduced by ***Abdallah and Adindani (1963).*** It's type locality is at southeast corner of North Galala Plateau. ***(El-Shazly et al., 1974 and Cherif et al., 1989)*** adopted the name Malha Formation to a sequence of sandstones that underlies the Cenomanian Galala Formation. ***Barakat et al. (1966)*** described Mallha Formation, as a Nubia "A" as the Upper part of Nubia sandstone. It is represented by alluvial near shore sandstones with minor clay and siltstone intercalation which rests unconformably over older strata. The sandstones that crop out below the marine Cenomanian beds are represented by stratified beds. ***Kerdany and Cherif (1990)*** suggested that the Malha Formation is made up of river deposits which carried clastic materials during a low stand of sea-level from the positive areas.



(Fig. 1) The location and geological maps of the study area at Wadi El-Dakhl, Zaafrana area, Eastern Desert, Egypt,

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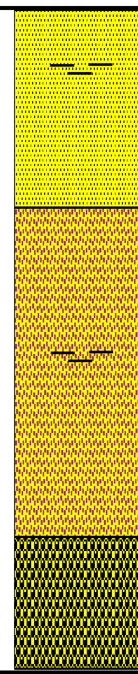
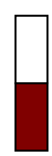
Silicate conversion coatings are prepared by immersing of hot deep galvanized steel sheets in sodium silicate of 1.00 to 4.00 mal. The coating with better corrosion resistance is usually obtained in silicate solution with higher molar ratio (3.00 – 4.00), ***Mei-rang Yuan et al. (2010).*** Sodium silicates has been used as an inhibitor and passivator to improve corrosion resistance of metals due to its effective inhibitory, friendly environmental and low costs, ***Nausha, A. et. al. (1998).*** the beneficiability of the Egyptian white sands by value addition to produce special types of sodium silicates used as corrosion and abrasion resistance coating. This article presents further research to use the produced sodium silicates as a double protective coating**.**

2-Lithostratigraphy

The Mallha Formation in the Wadi El-Dakhl area represented by 100 m. thickness of the most pure white sands. SiO_2 is about 99.6 to 99.8% in form of horizontal beds alternate with some intercalation of kaolinite and sandstones. It overlies the Jurassic age and underlies the Raha Formation **(Fig. 2).** It consists of very white sequence of stratified, cross-bedded and graded bedded sandstones, **(PL 1; Figs. A&B).**

Age	Formation	Sample No.	Thickness (m)	Lithology	Description
Late Cretaceous	**Raha**				
Early Cretaceous	Malha	**10** **9** **8** **7** **6** **5** **4** **3** **2** **1**	100 meter		Sandstone: white, fine grains, friable, non-fossiliferous, cross bedded and some kaolinitic intercalations.  **0** **20 m.** Sandstone: white, fine to medium grains, friable, non-fossiliferous, cross bedding, and rare kaolinitic intercalations. . Sandstone: white, medium to corss grains, friable, non-fossiliferous and cross bedding.
Jurassic					

(Fig. 2) Lithostratigraphic column of study area at Wadi El-Dakhl, Zaafrana area, Eastern Desert.

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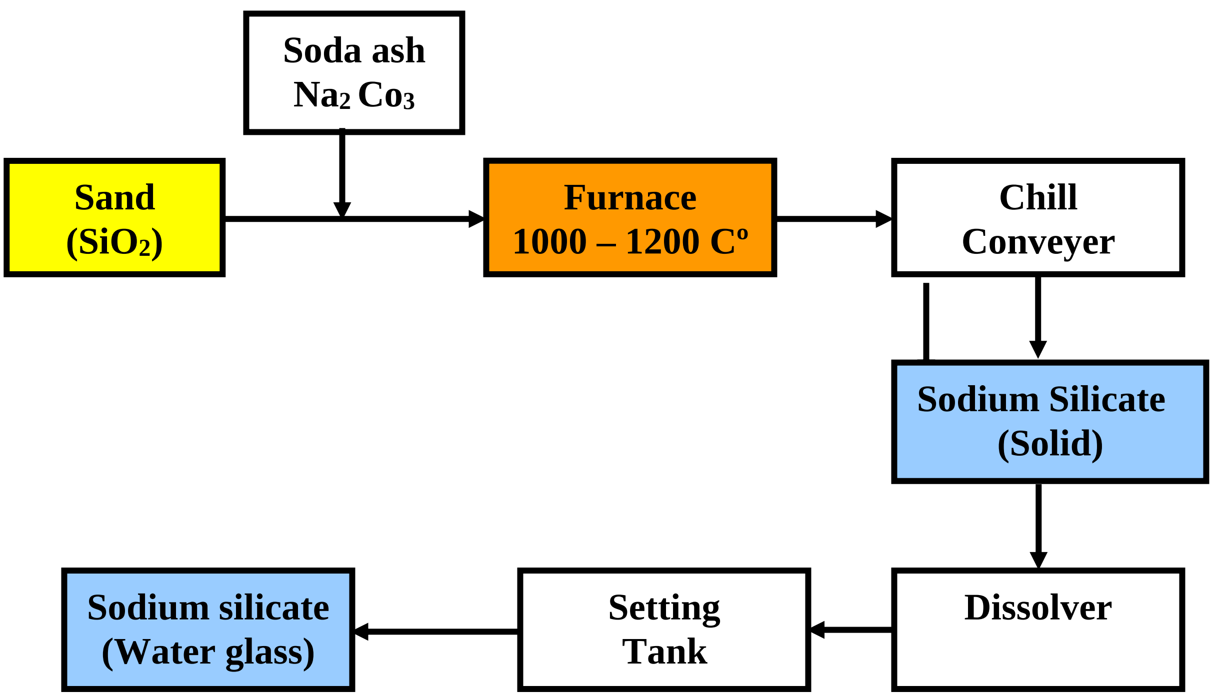
Plate (1)

(Fig. A&B) Field photographs showing white sands (Malha Formation in Wadi El-Dakhl, Zaafrana area, Eastern Desert, Egypt.

3. *Manufacturing of sodium silicate using of white sands.*

Pure white sand (SiO_2 ranging from 99.6% to 99.8) was collected from some localities at El-Dukhal area to prepare the special type of sodium silicates with special physical and chemical properties at the Egyptian company for chemicals (E.C.C.) Factory, **(Fig. 3).**



(Fig. 3) Diagram illustrates the perpetration of sodium silicates from white sand.

4-Methodology

4.1 Mineralogical analysis:

4.1.1. X-Ray Diffraction (XRD)

The studied three samples of collected white sand and one manufactured sodium silicates sample were subjected to X-ray diffraction (XRD). The analysis was achieved out at Central Laboratories Sector in the Egyptian Mineral Resources Authority. The XRD analysis carried out for powder sample (200μ) using a X-ray diffraction equipment with Ni-filter, Cu-radiation ($\lambda = 1.542$) at 40 KV, 30 MA and a scanning speed 0.02º/S. The reflection peaks between $2\theta = 4^{o}$ and 60^{o} were obtained. (X-Ray Diffraction Laboratory (XRD) (PW 1710 &X-pert pro MPD).

4.1.2. Scanning Electron Microscope (SEM)

Three samples of sodium silicates were investigation by SEM to illustrate their morphology by the aid of SEM and EDX petrology Atlas ***(Welton, 1984).*** SEM was also determined out at the Central Laboratories Sector in the Egyptian Mineral Resources Authority, Model Philips X30 attached with EDX unit, with accelerator voltage 30 KV magnification 10X to 400,000 and resolution for W. (3.5mm.).

4.2. Chemical analysis.

4.2.1. X-ray fluorescence (XRF)

Five samples of white sand and three of produced sodium silicates were subjected to (XRF) at Central Laboratories Sector in the Egyptian Mineral Resources Authority. The XRF analysis was carried out for powder (< 74 μm) samples using X-Ray fluorescence equipment PW 2404 with six analyzing crystals. Crystals (LIF-200), (LIF-220) were used for estimating Ca, Fe, K, Ti, Mn and other trace elements from Nickel to Uranium while crystal (TIAP) was used on determine Mg and Na. Crystal (Ge) was used for estimating P and crystal (PET) for determining Si and Al and PXI for determining Sodium and Magnesium. Ten carbon steel test panels (150mm X 150mm X 5mm) were hot deep galvanized at energy a steel fabrication Co. (galvanized plant) Egypt. The thickness of the zinc coating measured by Elcometer thickness gauge was average 35µm. The hot deep galvanized samples were immersed in the specified sodium silicate liquid at room temperature 25 °C for 5 min., and transferred to dry at room temperature 25: 30 °C. After drying 5 panels were treated and coated by sodium silicate (brush application) until the wet film thickness reached 50 µm.

4.3. Hardness test:

The hardness tests are carried out for samples of sodium silicates at Mechanical and Welding Lab, Metallurgical department; Engineering Collage-Cairo University using HLN-11A instrument serial no. A091602090.

4.4. Salt level test (on prepared surface):

The salt level tested by (Elcometer 130 SCM 400 salt contamination Meter**)** according to ***ISO 8501 – 2, 1994.*** This test is carried out for three samples at PETROJET in painting Yard lab. (Port Said).

4.5. Specific gravity

The specific gravity using ***ASTM D 1475, 1998*** is carried out in PETROJET concrete, coating plant (Port Said).

4.6. Appearance/ color

The color of our samples is tested in Egyptian Petroleum Research Institute.

4.7. Flash points

The flash point of our samples is tested in Egyptian Petroleum Research Institute.

4.8. Flammability

The flammability of our samples is tested in Egyptian Petroleum Research Institute.

4.9. Spreading rate

The spreading rate test is carried out for three samples at PETROJET in painting Yard lab. (Port Said).

4.10. Volume of solid content

The volume of solid content using ***ASTM D 2369, 1998*** and ***ASTM D 2697, 1998*** is carried out in PETROJET concrete, coating plant (Port Said).

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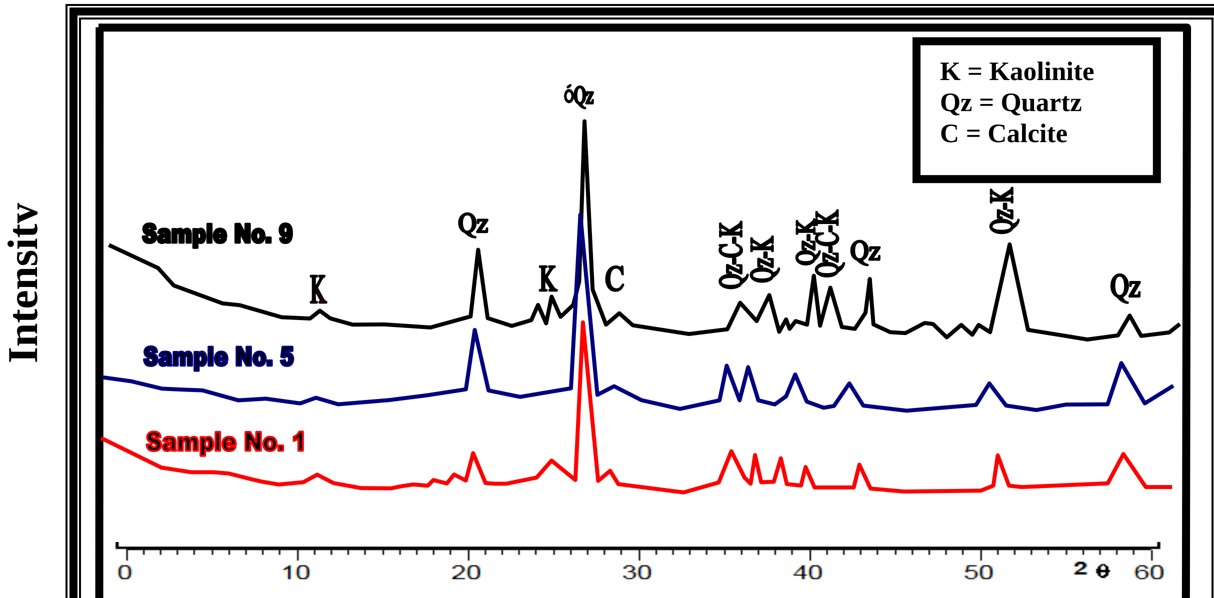
5. Result and Discussion

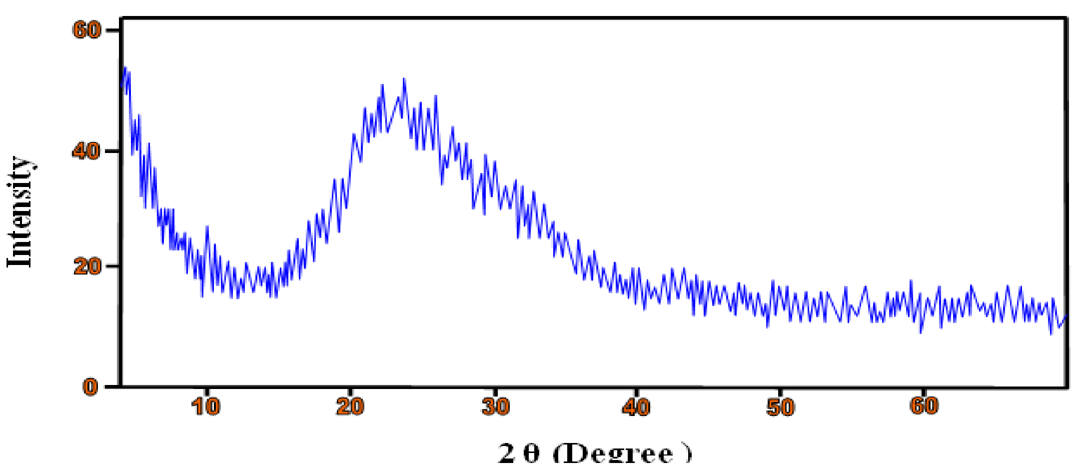
5.1. Mineralogy:

The mineralogical analysis of the studied white sand and sodium silicates samples were conducting via the X-ray diffraction analysis (XRD). The minerals identified from the bulk analysis of the white sand and sodium silicate samples are illustrated in **(Figs. 4&5).** Figure No. 4, illustrated the white sand mineralogical composition by using ***ASTM card No. 5-0490*** for quartz as a major element, ***ASTM No. 5-586*** for calcite as a trace element and ***ASTM No. 5-565*** for kaolinite as a trace element. Figure No. 4 for sodium silicate using ***ASTM No. 00-018-1240.***

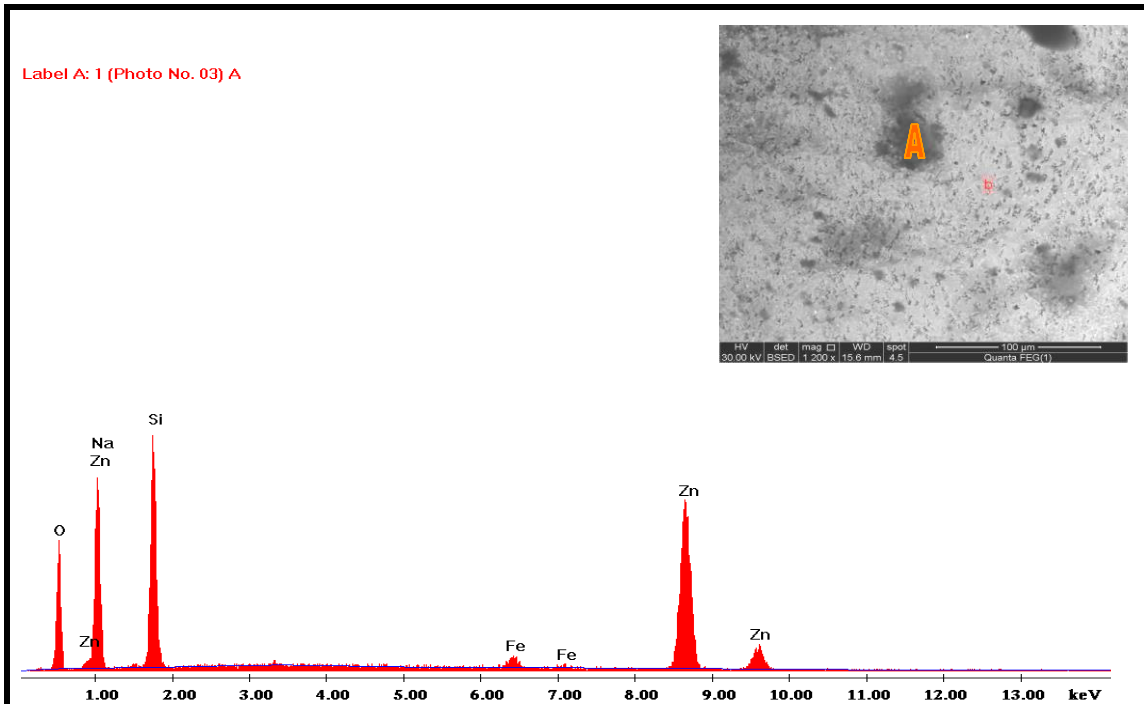


(Fig. 4) X-ray diffraction of representative bulk white sand samples No. 1, 5 & 9 of Malha Formation white sand from Wadi El-Dakhl, Eastern Desert, Egypt.

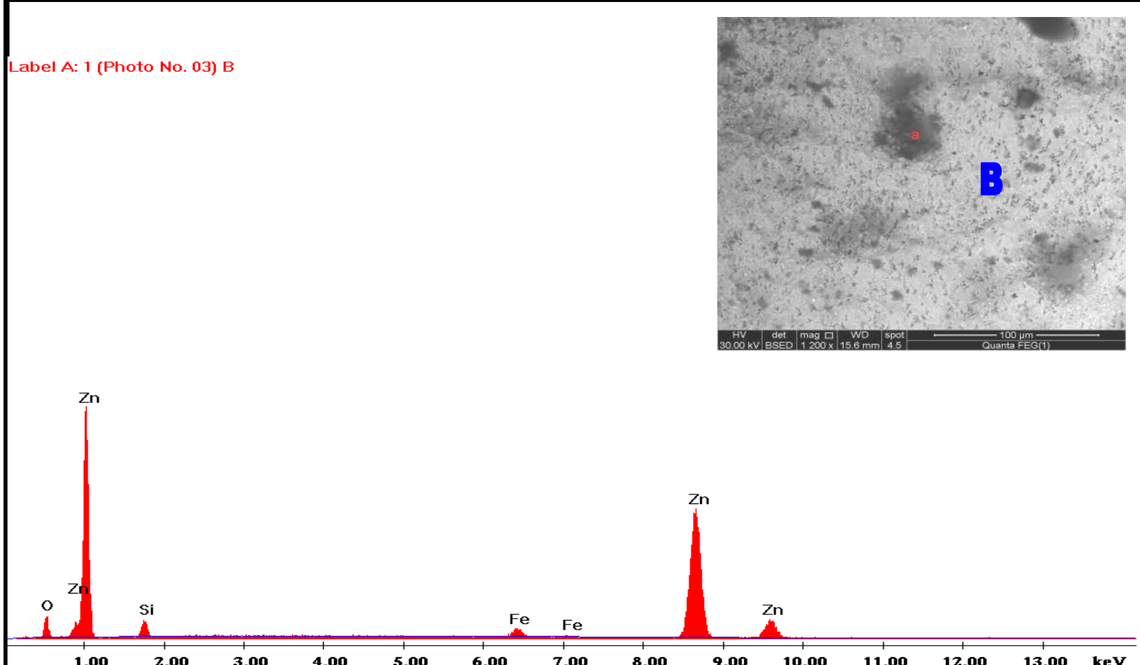
SEM & EDX of galvanized steel treated and coated by sodium silicate for three samples are showing in **(Figs. 6, 7&8).** The SEM was used to show the homogeneity and smoothing of silicates coating which is transparent with no coating defects, **(Fig.6).** SEM images showing a detail of the cross section of the steel galvanized surface coated by silicate, silica layered upon steel and zinc, the silicate shows good adhesion on the substrate surface and the EDX curves shows clearly the presence of Si, Zn, Na and Fe, **(Figs 6, 7&8).**



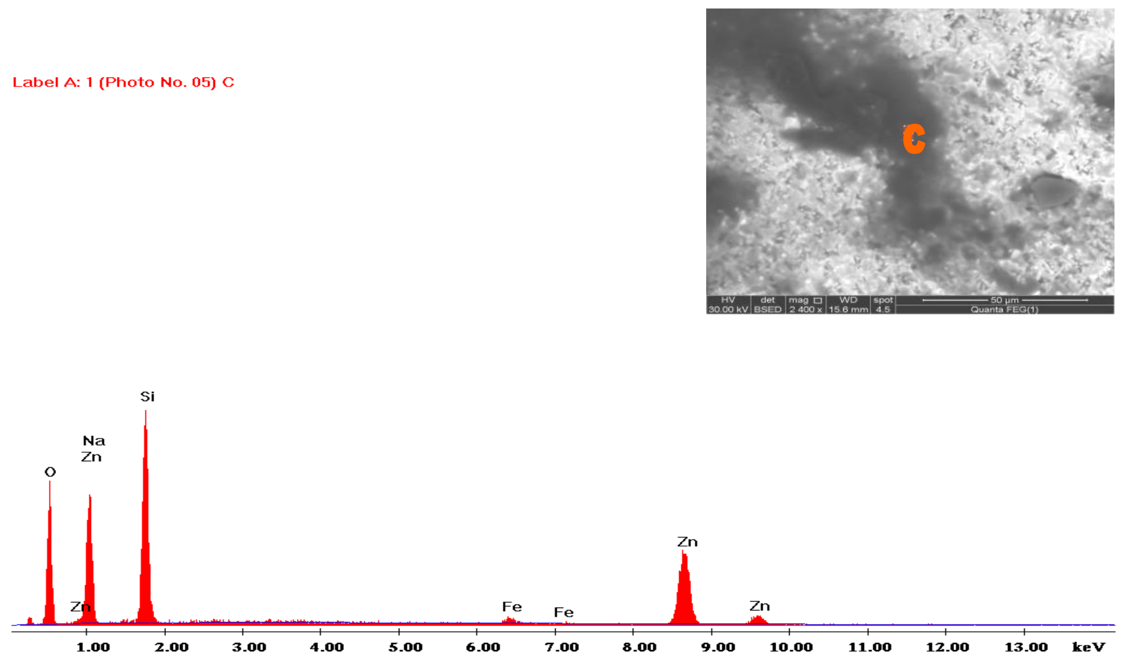
(Fig. 5): XRD diffraction of manufactured sodium silicates.



(Fig. 6) SEM & EDX of galvanized steel treated and coated by sodium silicate, sample A.



(Fig. 7) SEM & EDX of galvanized steel treated and coated by sodium silicate, sample B.



(Fig. 8) SEM & EDX of galvanized steel treated and coated by sodium silicate, sample C.

5.2 Chemical Analysis:

Pure white sand (SiO_2 ranging from 99.6% to 99.8) was collected from some localities at El-Dakhl area, **(Table 1).** The major oxides (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, Cl, SO_3 and L.O.I) were determined in the studied sodium silicate, **(Table 2).** In this table the percentage of SiO_2 and Na_2O represent by more than 99% and the other elements are less than 1%.

Table 1: Chemical analysis of major elements of white sands.

S. No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	SO_3	L.O.I
9	99.60	0.00	0.11	0.021	0.010	0.02	0.03	0.01	0.00	0.00	0.01	0.02
7	99.72	0.00	0.12	0.023	0.012	0.03	0.02	0.0	0.00	0.00	0.02	0.03
5	99.68	0.00	0.13	0.027	0.013	0.01	0.01	0.0	0.00	0.01	0.02	0.01
3	99.8	0.00	0.12	0.025	0.011	0.04	0.01	0.02	0.00	0.00	0.01	0.04
1	99.7	0.00	0.11	0.028	0.01	0.03	0.02	0.01	0.00	0.01	0.02	0.03

Table 2: Chemical analysis of major elements of sodium silicates.

S. No.	**SiO_2**	**TiO_2**	**Al_2O_3**	**Fe_2O_3**	**MnO**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**P_2O_5**	**Cl**	**SO_3**	**L.O.I**
1	**80.67**	**0.01**	**0.12**	**0.01**	**0.01**	**0.09**	**0.01**	**18.41**	**0.02**	**0.02**	**0.03**	**0.14**	**0.04**
2	**80.56**	**0.00**	**0.13**	**0.00**	**0.01**	**0.08**	**0.01**	**18.52**	**0.01**	**0.00**	**0.02**	**0.12**	**0.03**
3	**80.72**	**0.01**	**0.11**	**0.01**	**0.00**	**0.07**	**0.02**	**18.46**	**0.01**	**0.02**	**0.03**	**0.13**	**0.04**

5.3 Hardness Test

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting, **(Table 3).**

In this search, because of the property (hardness more than 9 Mohr) of our materials to resist abrasion effect of the windy sands in the aggressive environments of the deserts in addition to the corrosion resistance of it by the adding of one coat about 30µm provides additional mechanical protection to the protected items.

Table 3: The average of sodium silicates hardness.

HV 10			The Average HV 10
1	2	3	
943	955	923	937

5.4 Salt level test (on prepared surface):

The salt level test results on prepared metallic surface are less 3 µgr/ cm2.

5.5 Specific gravity

The ratio of the mass of a solid or liquid to the mass of an equal volume of distilled water at 4°C (39°F) or of a gas to an equal volume of air or hydrogen under prescribed conditions of temperature and pressure, also called relative density. The specific gravity of samples is ranging from 0.825 to 0.845 gr/cm3.

5.6 Appearance/ color

Appearance is composed of color, gloss, and texture. All three factors are important in visual uniformity of products. Color can be measured with a colorimeter and gloss with a gloss meter, Egyptian Petroleum Research Institute (EPRI) samples color is colorless.

5.7 Flash point

The lowest temperature at which a liquid in a specified apparatus will give off sufficient vapor to ignite momentarily on application of a flame, EPRI samples are have not flash points because it is water base.

5.8 Flammability

Historically, flammable and inflammable mean the same thing. However, the presence of the prefix in- has misled many people into assuming that inflammable means "not flammable" or "noncombustible", sodium silicate curing compound material is not flammable because it is water base.

5.9 Spreading rate

The area covered per unit amount of coat applied. Spreading rate is usually expressed as square meter per litter, also the surface area which can be covered by a given quantity of coating material to give a dried film of requisite thickness. The theoretical spreading rate (m^2/L) for a given dry film thickness can be calculated from:

$$\mathbf{m^2/L = volume\ solids * 10 / D\ F\ T}$$

Where: m^2 = square meter.
L = Litter.
DFT = Dry Film thickness.

The actual spreading rate measured after the application was found 12 m^2 / litter.

5.10 Volume of solid content

The mass, expressed as a percentage of the original mass of coating materials, which under specified conditions remains to constitute a dry film.

$$\mathbf{DFT = WFT * solids\ volume\ \%\ / 100}$$

Where: DFT = Dry Film thickness.
WFT = Wet Film thickness.

The actual volume of solid content after application and thickness measuring is found 30% average. Appling of one full coat 30 µm of sodium silicate by airless spray or by brush gives more mechanical protection against the abrasion effect of sand grains during the sandy winds of the steel galvanized items, **(Plate 2).**

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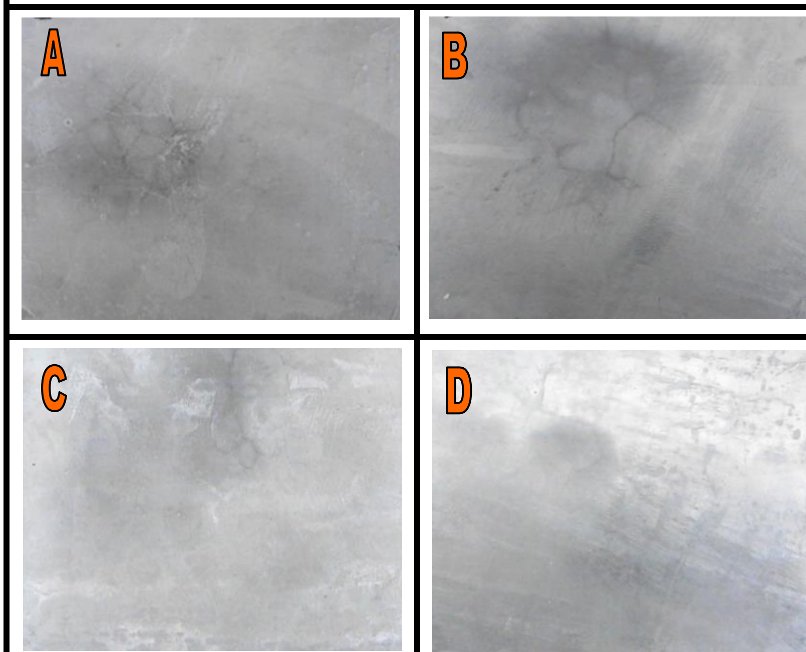
Plate (2)



(Figs. A&B): Photograph showing test panels of steel galvanized surface treated by sodium silicate.
(Figs. C&D): Photograph showing test panels of steel galvanized surface treated and coated by sodium silicate.

6. Conclusions

In the present study, we study how to find new industrial using of the Egyptian white sands as protection coating for steel surfaces exposed to aggressive weathering conditions. Preparation and manufacturing of special type of sodium silicates to use as a corrosion and abrasion resistance coating by using of white sands collected from Wadi El-Dakhl area related to Malha Formation-Early Cretaceous, successfully used as protective coating. The high stability and hardness of the produced sodium silicate offer a good protective coatings when it's applied over the steel surfaces. The use of pure SiO_2 reaches 99.8% of some white sands help us to produce high quality special type of sodium silicate suitable to use as good mechanical protection coating.

7. Recommendation

After the lab testing and field inspection by the coating & painting technical team of EPRI it recommended using the produce as good double protective coating for carbon steel items expose to aggressive weathering conditions.

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