

# A Review Article on the Influence of the Electrostatic Precipitator Cement Kiln Dust Waste on the Environment and Public Health

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**Abstract:** The electrostatic precipitator cement kiln dust waste (EPCKD) which is a byproduct coming from the different cement factories. This waste is a very dangerous material on the environment and also on the human health, where it causes air, water and soil pollution in the area surrounding the cement factories in Egypt and all over the world. So, the main objective of this review is to show the very huge amounts of the EPCKD waste accumulated behind the kiln filters and its negative effect on the environment. Also, the review illustrates the various diseases from which the inhabitants are suffering. Finally, the review shows as possible the different fields of applications in which this very dangerous material was utilized successfully, particularly in the field of building materials.

**Keywords:** Cement Kiln Dust, Environment, Health

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## 1. Introduction

Over the past sixty years, rapid scientific and technological advances in industrialization, particularly the cement industry, have been occurred all over the world. The cement industry has not only registered a tremendous pace of growth, but has also been in the forefront in adopting technological innovations. The technological advanced adopted by the industry pervade the entire cement manufacturing process right from winning of the raw materials to the ultimate packing and dispatch of cement. In a capital intensive industry like cement which requires huge quantities of raw materials of specific grade for the profitable manufacturing and marketing of the product, the economics of cement plant operations calls for an accurate assessment of the quality, quantity and mine ability of the minerals and rocks that go into preparation of feed of cement kilns. This is of paramount importance as the plants themselves are very sophisticated and individual components and sub-systems operate under very stringent parameters. Unless these parameters are met the efficiency of costly equipment is adversely affected. Thus, even after investing millions of dollars, the plant will

not be able to produce cement at the lowest cost and compete with other players in the industry. When considering the current scenario in most countries where supply outstrips demand, the results will be disastrous [1, 2].

As a result, new environmental and health problems were created particularly those come from air pollution. Air pollution has excited from many countries but recently, it becomes much more severe and has adverse effects on man's health, animals and plants, and also on materials or other environmental media [2-4]. Nowadays, because of growing industrialization, population and prosperity, the intensity and type of air pollution has globally increased. In Egypt, until now only few and scattered efforts have been made to study the effect of industrialization on the atmosphere in Cairo and the two neighboring industrial areas, namely Helwan and Shubra El-Kheima. These efforts were done in order to prevent or at least to reduce emissions of specific pollutants from selected sources. In spite of such efforts, both the amounts and the different air contaminating substances have continuously increased by time [4-6].

Cement industry is one of the most intensive energy consuming industries. The dry process with precalciner

represents the most up to date technique for Portland cement clinker manufacture with high productivities and low specific heat consumption [4, 7]. However, such process is characterized by the high intensity of the circulation phenomena of secondary constituents as alkalis, chlorine and sulfur between the preheater-calciner and the kiln if compared to other techniques such as semi-dry, semi-wet, long-dry and Lepol kiln techniques [8, 9]. During these processes, a large amount of airborne dust (1000tons/day) in

Assiut cement company as an example may be generated as a waste [10]. The bypass dust is produced as a solid waste material from the preheater bypass systems by using the dry process as a result of some minor volatile constituents in the kiln feed and fuel (Figure 1). Figure 2 demonstrates the collection and transportation of the cement dust. The properties of this bypass dust waste depend mainly on the kind of raw materials and the fuel used as well as on the production method and the kiln type [11].

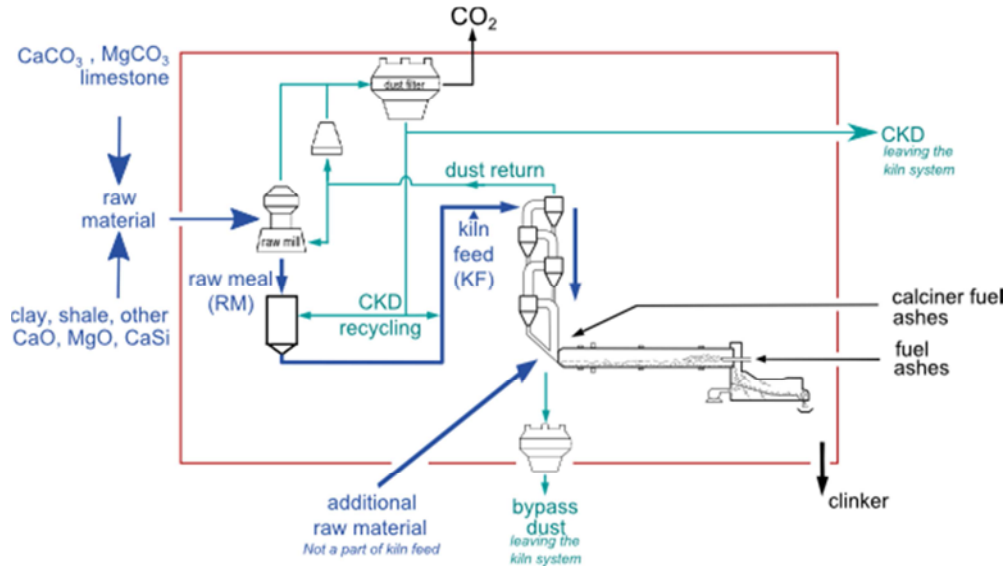


Figure 1. A systematic diagram showing the discard of the bypass dust waste.

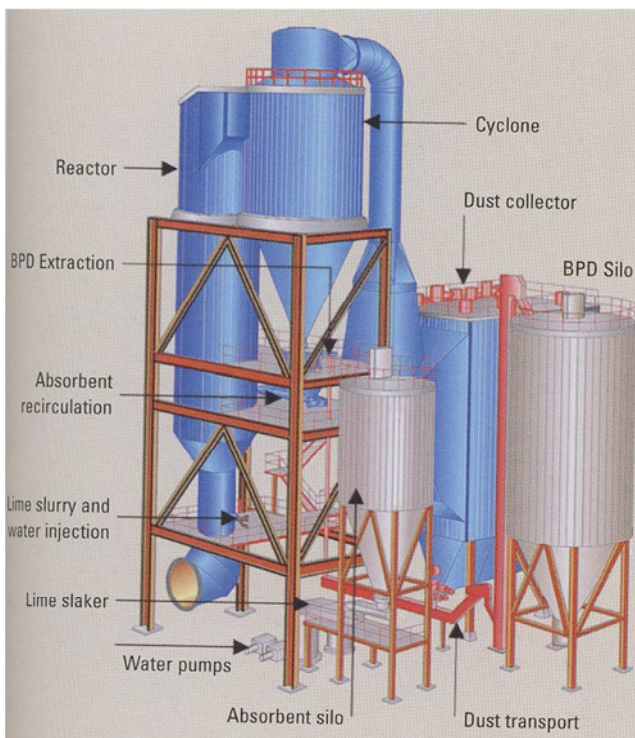


Figure 2. A simple picture showing the collection of Cement dust.

One of the main air pollution is the cement kiln dust (CKD) that coming from the manufacture of the various types of cement. During the last two decades, there has been

a simultaneous increase of cement kiln dust and also the ability to measure the chemical constituents with greater accuracy the wide spread use of mathematical models for establishment the transport and diffusion of air pollutants over large regional or continental scale areas [3, 4].

## 2. Amounts of CKD Waste in Egypt

The CKD waste which is exhausted from the cement industry has very fine particles and a tendency to suspend in the atmosphere for a long time. Therefore, it can fly and spread over a wide area very easily even by means of very weak winds. Also, the CKD waste has high alkali content. Accordingly, it causes deleterious effects for the various bioecosystems. Not only does it cause air pollution, but also it causes a very serious economic problem to all cement production companies. This is due to the accumulation of very huge amounts like hills of that CKD behind the kiln filters which approximately reach about one and half million ton yearly or may be little more. Table 1 shows the daily production of cement kiln dust waste (CKD) in some of the various cement factories in Egypt [3, 4].

As it is clear, the total amount of cement kiln dust waste in some of the cement factories as shown in Table 1 is about 5700 Tons /day. In Egypt, the total amounts of the cement kiln bypass dust waste are about 3.5 million tons yearly. In United States of America USA and UK, the total amount of CKD waste is about 12 and 8 million tons yearly,

respectively. Generally, about 18 wt. % of the feed kiln materials may be purged as a waste [12-14].

**Table 1.** The daily amounts of cement kiln dust waste (CKD) produced in some of the Egyptian cement factories.

No.	Factory	Tons / day
1	Tourah Cement Company	350
2	Helwan Cement Company	550
3	National Cement Company	650
4	Alexandri Cement Company	200
5	Suez Cement Company	300
6	Titan Cement Company	650
7	Cemix Cement Company	350
8	El-Amria Cement Company	300
9	El-Menia Cement Company	250
10	Al-Arabia for Cement	350
11	Al-Sweedy for Cement	300
12	South Valley for Cement	400
13	Arabian Cement Company	250
14	Assiut Cement Company	1000
	Total	5700

Accordingly, the cement kiln dust waste represents a heavy burden for all cement factories due to its disposal character and environmental effects. Moreover, great efforts are needed to transport it far away. To get rid of these huge quantities of the cement kiln bypass dust waste, it is usually collected and placed in the open desert areas. As a result of that the cement dust return back in the direction of winds or storms causing the air pollution in the close dwelling zones over which the dust particles were precipitated. This is mainly due to the very fine grain size of cement kiln dust particles which make it difficult to precipitate easily and still suspended in the air for a long time causing what is known as air pollution. The dangerous effect of cement kiln dust waste is due to the high alkali content ( $\text{Na}_2\text{O}$ , 2.11 and  $\text{K}_2\text{O}$ , 2.2). Table 2 illustrates the chemical analysis of the cement kiln dust waste in different local plants. It is clear that the total alkali content ( $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$ ) in all cement factories is high which is essentially responsible for the environmental and health hazards.

**Table 2.** The chemical composition of the CKD waste in some local cement companies.

Cem. Plant Oxide	Plant (1)	Plant (2)	Plant (3)	Plant (4)	Plant (5)	Plant (6)	Plant (4)	Plant (8)	Plant (9)	Plant (10)
$\text{SiO}_2$	12.14	11.70	13.12	11.79	13.05	12.66	13.21	12.83	12.91	12.84
$\text{Al}_2\text{O}_3$	1.86	1.49	1.52	1.27	1.61	1.73	1.78	1.56	1.94	1.86
$\text{Fe}_2\text{O}_3$	1.13	1.51	1.64	1.23	1.43	1.54	1.61	1.68	1.55	1.53
$\text{CaO}$	52.32	54.14	53.25	52.96	50.98	51.99	52.57	54.35	53.11	52.51
$\text{MgO}$	1.87	2.14	2.06	2.11	2.03	2.21	2.24	2.31	1.92	1.84
$\text{MnO}$	0.06	0.01	0.02	0.07	----	0.02	----	0.01	0.03	----
$\text{Na}_2\text{O}$	1.65	1.72	1.22	1.34	1.64	1.41	1.21	1.61	2.33	1.65
$\text{K}_2\text{O}$	2.36	1.86	1.54	1.48	2.02	2.11	2.13	1.89	1.98	0.83
$\text{SO}_3$	1.89	1.06	1.21	1.02	1.18	1.65	1.44	1.71	1.78	2.43

### 3. Dust Precipitation

A Survey [4] was made to measure and calculate the rates of the dust precipitation in the region of Helwan, where the precipitated dust was approximately 100 tons / a square kilometer. Also, the suspended dust in air inside the dwelling zone of Helwan was 1.35 milligram / a cubic meter of air, whereas the permissible limit at most industrial areas is limited only by the value of 0.2 milligram / a cubic meter of air. Furthermore, the concentration of dust particles in air within the disc zone was also measured throughout the day light, which was found to reach a value of about 700 and 1200 million particles of dust in one cubic meter of air at Maasara city in the northern and southern parts of Helwan, respectively. If these values are compared with the recorded maximum permissible limit for people exposure, which is stated to be in the ranger of only 60 particles of dust /a cubic meter of air, we can conclude that these values indicate clearly the seriously higher extent of air pollution situation to which Helwan region had been suffered.

### 4. Health Effects

In addition, a survey was carried out on the inhabitants of Helwan region so as to study and recognize the biological and health effects that caused by means of breathing the

polluted air with the suspended dust coming from cement, pipes, iron and steel industries which surrounded the area of Helwan [4]. This study deduced and revealed that the seriously air pollution condition in Helwan region caused the great spreading of several and very dangerous diseases. It was found that about 29% of inhabitants suffered from the respiratory system diseases such as Enfluenza with fever, acute and chronic bronchitis, bronchial athma and pulmonary inflammation. Moreover, the exposure to silica can produce silicosis, which is a debilitating respiratory disease. About 14% of inhabitants suffered from some of the digestive system diseases such as: Acute and chronic diorrhoea. About 10% suffered from infectious diseases such as Typhoid and paratyphoid, measles, small box, mumps, whooping cough, amaeoid and bacillary of dysentery. About 9% of people have skin diseases and another 9% have heart and its blood circulatory system diseases. The skin and heart diseases cause an allergy which is considered one of the most well known skin diseases. Such impure atmosphere of Helwan region essentially affects the heart and its blood circulation to a great extent. Moreover, the pregnant women and their fetuses are often the most survivors suffering from these diseases. They always expose to abortion. Even, if the birth occurred, the baby will be weak and scrawny and will suffer from respiratory and thoracic chronic diseases and may be lost his life. Also, the children became scrawny and weak.

## 5. Fields of Applications

Recently, the general trend all over the world is the reutilization of the various industrial wastes or by products in useful applications to prevent or at least to reduce or generally to avoid the environmental pollution. Darweesh [4, 15, 16] studied the effect of Cement Kiln Dust addition (CKD) on the physical properties in terms of water absorption, bulk density and apparent porosity (Figures 3-5), mechanical properties in terms of bending strength (Figure 6) and thermal properties in terms of dry and firing shrinkages (Figure 7) on the properties of ceramic products containing it. He concluded that the addition of 5 wt.% up to 25 wt.% CKD waste to the ceramic body does not change the dry shrinkage but improved and enhanced the specific properties of the ceramic article containing it. They also found that the only adverse effect of CKD addition is the relatively higher rate of firing shrinkage that could be taken place in the ceramic body with the increase of CKD content (Figure 7).

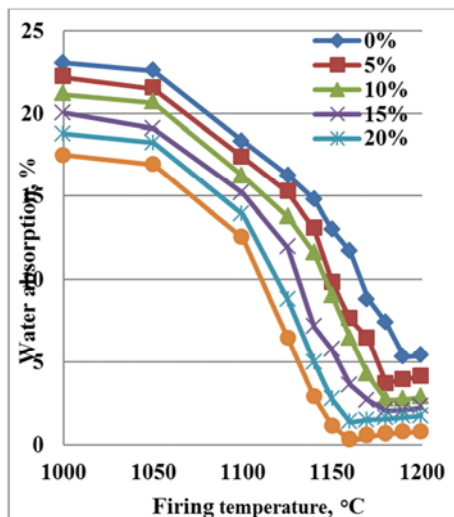


Figure 3. Water absorption of the fired ceramic bodies containing different cement dust contents.

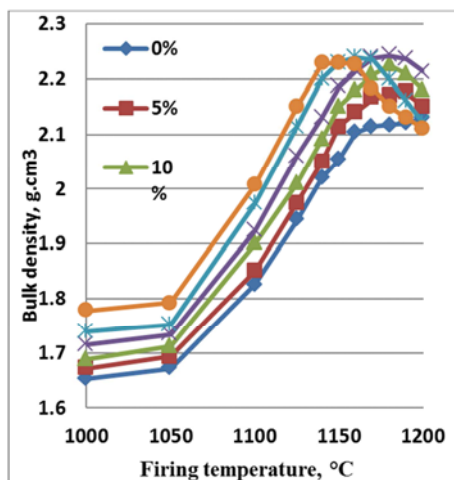


Figure 4. Bulk density of ceramic bodies containing different cement dust contents.

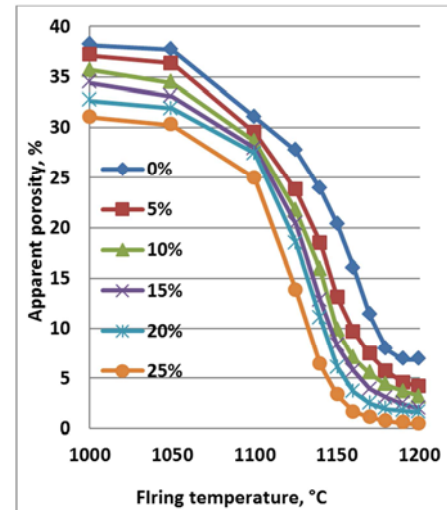


Figure 5. Apparent porosity of Ceramic bodies with different CKD contents.

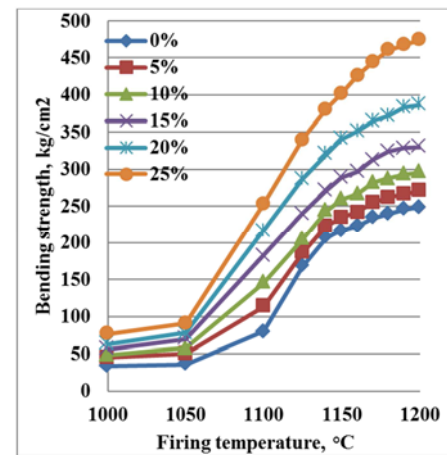


Figure 6. Bending strength of fired ceramic bodies containing cement dust at different firing temperatures.

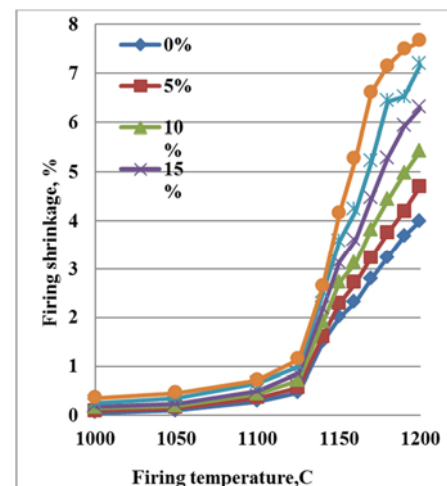


Figure 7. Firing shrinkage of ceramic bodies containing different cement kiln dust contents.

Darweesh and khalil [17] illustrated that the addition of 5-10 wt.% CKD waste to the Alumina cement improved the specific properties of the cement hydrated up to 28 days in terms of chemically combined water content, bulk density, apparent



porosity, compressive strength, but the higher amounts of CKD content more than 10 wt.% reflected negatively on these properties. Darweesh [16] also investigated the influence of cement kiln dust addition on the physicochemical and mechanical properties of Portland and Slag cements. He found that the addition of more than 5 wt.% or 15 wt.% CKD waste to OPC and Slag cements had adverse effects of the physical, chemical, mechanical properties as well as the durability of the cement, respectively. Darweesh et al. [14, 18] studied the densification parameters, thermal and mechanical characteristics of conventional ceramic products (Wall and floor tiles) containing different ratios of CKD and other waste material (Homra, H). They concluded that the addition of 10 wt.% CKD waste improved all physical properties in terms of water absorption, bulk density and apparent porosity (Figures 8-10), and also mechanical properties in terms of flexural and crushing strengths (Figures 11 and 12) of the resulted products and then adversely affected. The dry shrinkage is unchanged with the incorporation of CKD and/or H, while the firing shrinkage is increased with the increase of its addition (Figure 13).

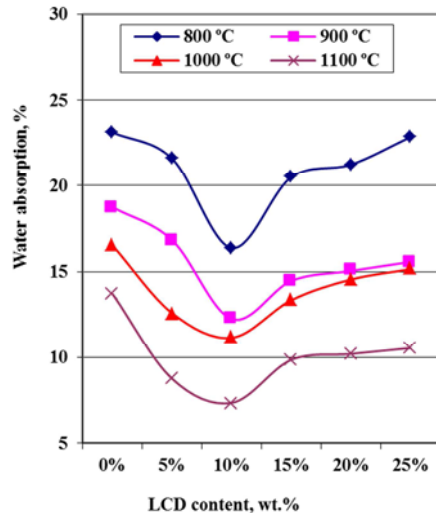


Figure 8. Water absorption of ceramic products with various LCD contents.

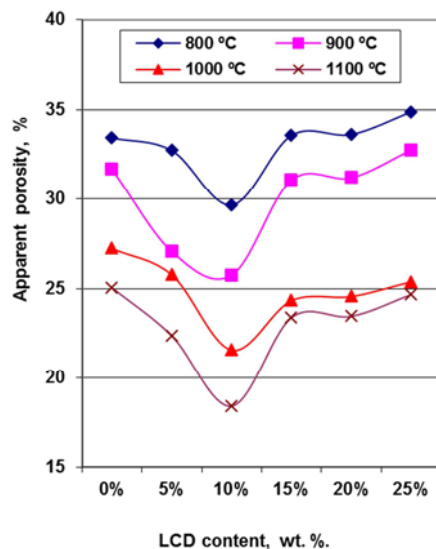


Figure 9. Apparent porosity of ceramic products with various LCD contents.

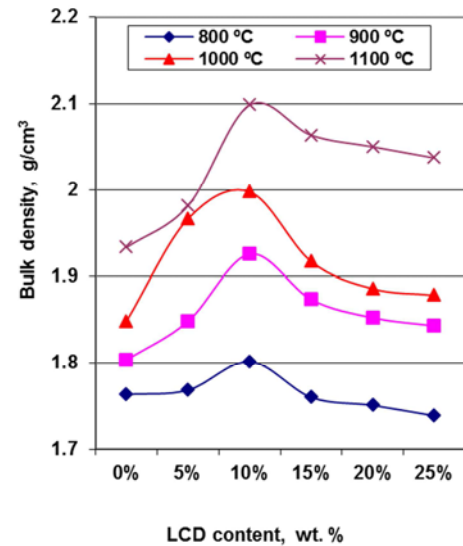


Figure 10. Bulk density of ceramic products with various LCD contents.

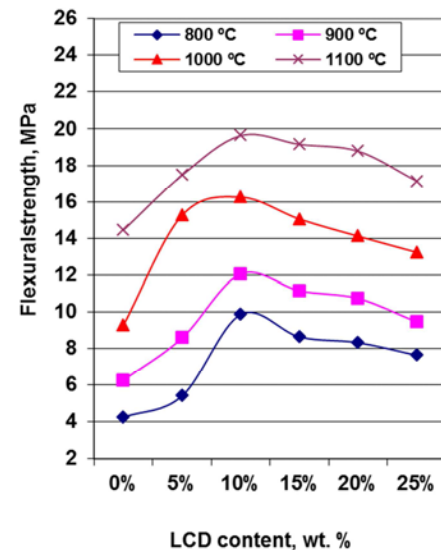


Figure 11. Flexural strength of ceramic products with various LCD contents.

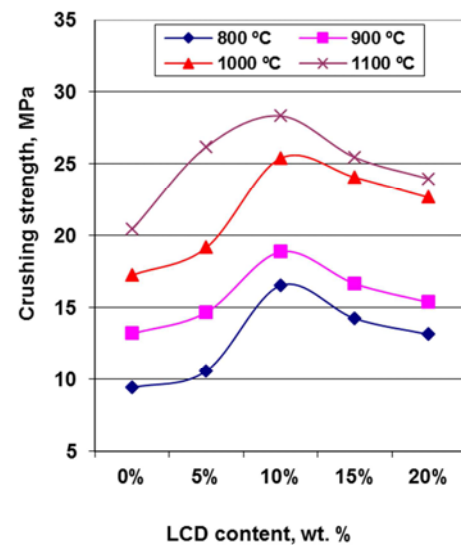


Figure 12. Crushing strength of ceramic products with various LCD content.

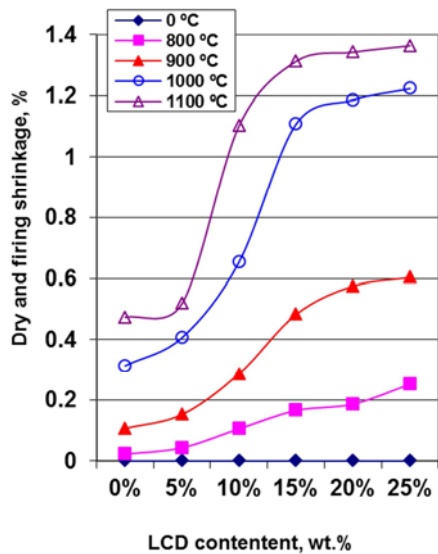


Figure 13. Dry and firing shrinkage of ceramic products with various LCD content.

The possibility to reuse the EPCKD waste as a source of CaO in the conventional ceramic industry was studied. He could be used about 20-25 wt.% of EPCKD waste to produce wall and floor tiles with good characteristics when compared with the control bodies. The physical properties in terms of water absorption, bulk density and apparent porosity, mechanical properties in terms of bending strength, thermal properties in terms of dry and firing shrinkage as well as thermal expansion were investigated. It is concluded that the addition of EPCKD waste improved and enhanced all the characteristics of the prepared ceramic bodies [14].

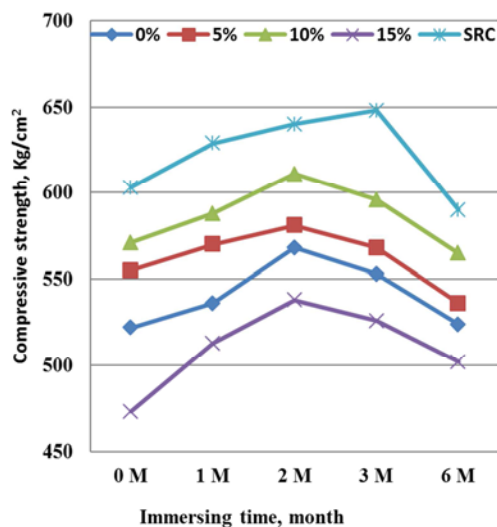


Figure 14. Compressive strength of slag rich cement pastes containing 0-15% CKD waste immersed in 5%  $MgSO_4$  soln. up to 6 months.

Darweesh [19] investigated the hydration, strength development and sulphate attack of some cement composites containing granulated blast furnace slag (GbfS) and EPCKD waste against 4%  $MgSO_4$  and 4%  $MgCl_2$  solutions up to 6 months compared with the sulphate resisting cement pastes (SRC) (Figures 14 and 15), respectively. The author

concluded that the presence of EPCKD waste improved the resistance of cement composites to  $SO_4^{2-}$  and  $Cl^-$  ions up to 2 and 3 months of immersion compared with the SRC which can withstand up to 3 and 6 months, respectively. Darweesh and Taha [20, 21] studied the possibility to reuse of the EPCKD waste in the production of Slag-rich cement and investigated the durability of these cements against some aggressive solution as 4%  $MgSO_4$ , 4%  $MgCl_2$  solutions and a mixture of these two solutions. They indicated that the resistance to  $MgCl_2$  is higher than that of  $MgSO_4$  solutions at all immersion times. El-Hemaly et al. [22] studied the incorporation of cement kiln dust to produce Portland and Blast Furnace slag cements.

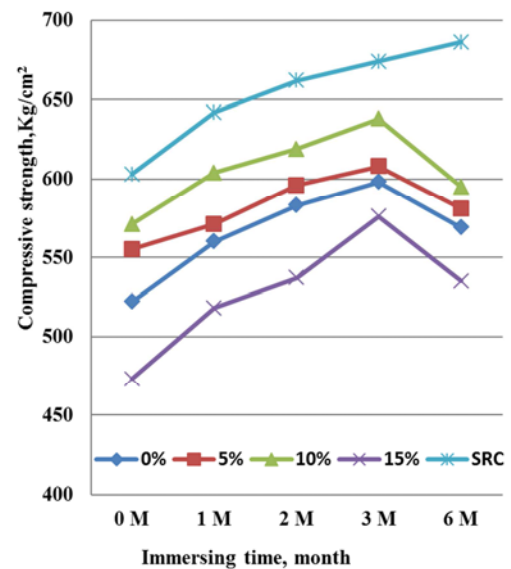


Figure 15. Compressive strength of slag rich cement pastes containing 0-15% CKD waste immersed in 5%  $MgCl_2$  soln. up to 6 months.

Also, Gommaa et al [23] studied the possibility to utilize the EPCKD waste in the manufacture of building bricks. They produced some types of building bricks using different raw materials with this cement dust waste as limestone and sand according to the Egyptian standards. Youssef [24] utilized the cement kiln dust waste in the manufacture of wall tiles while Ali and Yang [25] utilized the same waste material in the manufacture of building bricks.

## 6. Conclusion

1. The electrostatic precipitator cement kiln dust waste (EPCKD) is a very dangerous material and it must take care when dealing with it due to its high alkali content ( $Na_2O$  and  $K_2O$ ) ranging between 2.0-3.7 wt.%.
2. To minimize the environmental pollution with the EPCKD waste and to get rid of its adverse effects on the human health and also on the environment itself.
3. On the other hand, the scientists all over the world must do their best to find more fields of applications to reutilize this dangerous waste material in useful purposes to avoid its negative influence on the environment and the human health.

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