

Assessment of the Environmental Effects of Berber Cement Factory (2018- 2022)

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Abstract:

In Sudan the cement industry is mainly occurred in River Nile state. From human health and local community safety sight of view, seasonal scientific research and serious environmental management may be important. The aim of this study was to assess the effects of Berber cement factory on the local environment as a case of study. Twenty four (24) soil samples were collected from three distances far from the factory at depths of 10 and 20cm for each geographical direction. Control samples were obtained for comparison. Flame photometry and atomic absorption spectroscopy techniques were used for analysis. The measured minerals were Na, K, Ni, Cd and Pb. Statistical analysis was carried for the obtained results using (SPSS) program. The mean concentrations of minerals around the factory were found to be, Na (10.7123ppm), K (11.0784ppm), Ni (0.1896ppm), Cd (0.0232ppm) and Pb (0.1191 ppm). The obtained results were all within the permissible accepted values. The concentrations of Na, K and Ni were higher than the control samples, whereas Pb and Cd concentrations were lower in the samples than the control.

Key words: Environment, Pollution, Cement, Heavy metals.

تقييم الآثار البيئية لمصنع أسمنت بربر

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 المستخلص:

توجد صناعة الأسمنت في السودان بصورة رئيسية في ولاية نهر النيل. من وجهة نظر صحة الإنسان وسلامة المجتمع المحلي ربما يكون مهما وجود بحث علمي وإدارة بيئية حازمة بصورة دورية. هدف هذه الدراسة هو تقييم الآثار البيئية لمصنع أسمنت بربر كنموذج دراسة. تم جمع أربع وعشرين (24) عينة تربة من ثلاث مسافات بعيدا عن المصنع بأعماق 10 و 20 سم في كل اتجاه جغرافي. جمعت عينات مرجعية من أجل المقارنة. استخدمت تقنيتا مضوائية اللهب و مطيافية الامتصاص الذري للتحليل. المعادن التي تم قياسها هي, Cd, Pb, Ni, K, Na. تم تحليل النتائج احصائيا برنامج (الحزمة الإحصائية للعلوم الاجتماعية). وجد أن متوسط تراكيز المعادن حول المصنع كالتالي, Ni (0.1896ppm) Na (10.7123ppm) K(11.0784ppm), Pb (0.1191 ppm), Cd (0.0232ppm). كل النتائج المتحصلة كانت في المدى المسموح به. وجد أن تراكيز كل من Ni, K في العينات أعلى مما هو في العينات المرجعية بينما كانت تراكيز الأيونين Cd, Pb أدنى مما هي في العينات المرجعية .

الكلمات المفتاحية : البيئة , التلوث , الأسمنت , الفلزات الثقيلة.

Introduction:

Worldwide there are many kinds of cements and concretes manufacturing. The main producer during the years 2004-2007 were China, India, USA, Japan, Russia, Korea, Spain, Turkey, Italy and Brazil, where of China produced about 50% of the total (Srivastava, 2012). Atbara cement factory was built in 1918 as a beginning of a modern industrial sector in Sudan. In the mid-2000s, cement imports were about 80 percent of total supply, but since (2010) Sudan eliminated imports of cement. Now Sudan produces cement from seven plants with a total capacity of seven million tons, five of those plants started their production in 2009/2010, most of them are owned by private investors to meet the demand in Sudan and markets of neighboring countries. In 2014, for the first time, Sudan exported 125 thousand tons of cement to get US\$12 million (African Development Bank Group,

2016). Environmental pollution is the emission of chemical waste that leads to deleterious effects on the environment and contains the atmosphere and the soil (Lagowski, 2004). Many pollutants Cement dust, toxic chemicals, heavy metals, and factories smoke all can deposit on soil (Jain and Jain 2006). During various processes in cement manufacture the dust produce from the raw mill exhaust, the cooler exhaust, and the cement mill exhaust, in addition to other emissions including nitrogen oxides, sulfur oxides, carbon oxides, total hydrocarbons, dioxins, furans, heavy metals like mercury, lead, zinc and water suspended solids may be generated from cement production (Charles and Bauka, 2004). Any Cement factory may generate 0.07 kg of dust in the atmosphere for each kg of cement (Addo et al., 2013). High concentrations of many minerals in cement dust lead to toxic effects on animals (Kesarwani and James 2017). Cement dust has health impacts on animals especially when exposed to the highly irritating SO₂ gas (Attri and Kalia, 2017). In addition to the decrease of production and quality of crops, heavy metals were also reported to support tumor and mutations to a large extent in animals through their effects on the quality of the atmosphere and water bodies which may get minerals from contaminated soils (Sardar et al., 2013). Clinker cooler, crushers, grinders, and materials-handling equipment are processes in cement production represent sources of air pollutants including nitrogen oxides, carbon dioxide, water, oxygen, dust, chlorides, fluorides, sulfur dioxide, carbon monoxide, hydrogen sulfide, dioxins, furans and heavy metals. Sulfur dioxides existing in cement raw materials and in the fuel, but emissions released from sulfur in the raw materials are lesser than that released from sulfur in the fuel Mishra and Siddiqui (2014).

The study area:

The study area around Berber cement factory which is located between latitude 17° 57' 3.29" to 17° 55' 26.08" N and longitude 34° 3' 35.67" to 34° 1' 53.46" E in the south eastern of Berber which is located in River Nile state, about 5300 m from the main

road. Temperature in the study area during the collection of samples were between 29°C and 31°C. (Figure 1) described the study area and sampling.



Fig: 1 The study and sampling area (Asmaa Elrasheed 2022)

Methodology

Twenty four (24) soil samples were obtained from different distances around the factory as 500, 1000 and 1500m from north, south, east and west direction at depths of 10 and 20cm for each site. Two samples were collected from a site located very far from the factory to serve as a control. Prior to laboratory analyses, samples were homogenized, pulverized, air dried and sieved through a 100-200µm stainless steel mesh. Samples were digested using a mixture of concentrated acids; the obtained solutions were filtered and diluted. Flame photometer and atomic absorption analysis used to measure soil minerals. All chemicals were of analytical grade.

Statistics

The elemental concentrations of samples were treated by statistical analysis to include descriptive statistical analysis, Pearson correlation matrix of the elements and MANOVA analysis. This was calculated using Statistical Package for Social Scientist (IBM SPSS statistic 20).

Results and discussion

Measured concentration of minerals in soil around factory and for control were listed in (Table 1). Whereas mean concentrations were listed in (Table 2) and graphed in (Figure 2).

Table 1 Minerals concentration around the factory and for control

Sample Element Sample	Na	K	Ni	Cd	Pb
1	3.699	3.588	0.099	0.018	0.226
2	3.497	1.947	0.084	0.016	0.138
3	2.391	26.860	0.250	0.007	0.073
4	1.879	3.041	0.676	0.006	0.083
5	5.315	33.380	0.444	0.018	0.108
6	5.519	3.041	0.153	0.007	0.144
7	3.497	2.858	0.519	0.014	0.294
8	9.271	16.620	0.294	0.012	0.198
9	3.939	23.140	0.306	0.028	0.035
10	3.079	23.140	0.180	0.033	0.033
11	2.391	4.813	0.274	0.029	0.145
12	2.563	5.186	0.149	0.033	0.189
13	7.895	7.420	0.143	0.008	0.094
14	9.099	6.676	0.204	0.046	0.114
15	6.519	18.485	0.010	0.015	0.072
16	6.519	7.048	0.041	0.006	0.095
17	41.110	24.065	0.036	0.008	0.115
18	46.270	12.552	0.060	0.011	0.072

Sample Element Sample	Na	K	Ni	Cd	Pb
19	27.350	12.552	0.075	0.011	0.161
20	54.870	3.697	0.201	0.183	0.050
21	2.563	9.096	0.010	0.016	0.035
22	2.219	5.931	0.096	0.012	0.108
23	2.563	6.862	0.203	0.015	0.036
24	3.079	3.883	0.043	0.006	0.241
C1	3.595	5.000	0.089	0.020	0.076
C2	4.627	3.697	0.148	0.031	0.167

Source: Asmaa Elrasheed (2022)

Table 2 Mean concentration of minerals around factory and for control (in ppm)

Metal	Na	K	Ni	Cd	Pb
Factory	10.7123	11.0784	0.1896	0.0232	0.1191
Control	4.1110	4.3485	0.1185	0.0255	0.1215

Source: Asmaa Elrasheed (2022)

In some samples relatively high concentrations were measured for some minerals, like sodium in samples 17, 18, 19 and 20, potassium in samples 3, 8, 9, 10, 15 and 17, nickel in samples 4, 5, 7 and 9, lead in samples 1, 7 and 24. Generally for samples all minerals concentrations were found below the 1996 WHO recommended limits of 100ppm for Pb, 3ppm for Cd and 80 ppm for Ni (Bello, 2016). Many studies reported that high concentrations of minerals are related to closeness of site to cement factory (Ogedengbe and Oke, 2011; Solgi, 2015). However the levels of mineral distributions depend on distances and directions from the cement facility and are a complex in pattern and many other factors, such as atmospheric transports and local meteorology, might also be effective (Onwudiegwu, Ezech and Obioh, 2016). The dust escaping from cement industries is often transported by wind and deposited in areas closed and far away from

the factory (Chaurasia, Karwariya and Gupta, 2013). According to Olowoyo, Mugivhisa and Busa (2015) effects and concentrations of the dust containing trace metals as pollutants vary and depend largely on technology employed from the cement industries to ameliorate environmental degradation. These metals originating from industrial activity are getting accumulated in upper layer depending on size and distance from origin (Zehra, et al., 2017). Soils containing large amount of colloidal organic and mineral material, can sorb and immobilize these metals to a greater extent than what soils with a low content of these reactive materials can retain (Shivakumar and Srikantaswamy 2012). Minerals concentration in soil can be due to the strength and direction of wind, cation exchange capacity, type of soil in which heavy metals adsorbed by initial fast reactions in minutes to hours then by slow adsorption reactions in days to years, so minerals can be redistributed into different chemical forms with different bioavailability, mobility, and toxicity (Michael et al, 2015), also gravity can contribute to differential deposition rate of metals on soil (Ogedengbe and Oke 2011). The distribution of minerals in the soil samples around the factory followed in decreasing order of $K > Na > Ni > Pb > Cd$, these results agree with those of Addo et al. (2013) who found that the concentration of Ni is greater than Pb.

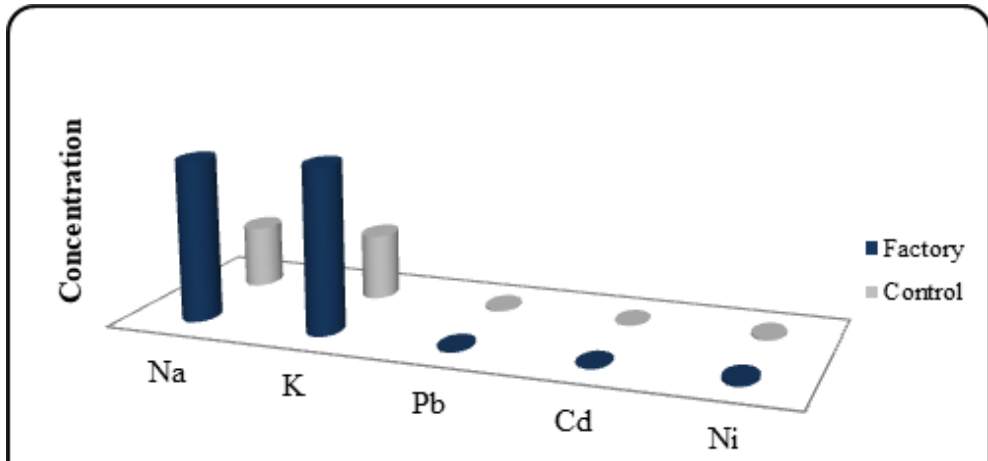


Fig: 2 Mean concentrations of minerals around the factory and for control

(Asmaa Elrasheed (2022)

Pollution evaluation

Evaluation of soil pollution was calculated using pollution index formula:

$$P_i = C_i / S_i$$

Where C_i represents the concentration of heavy metal (i) in soil, while S_i indicates the relevant standard value for this metal (WHO1996).

Soil contamination level, using this index P_i , was classified into four grades: $P_i < 1$ unpolluted, $1 \leq P_i < 2$ is considered as slightly polluted, $2 \leq P_i < 3$ considered as medium polluted, and $P_i \geq 3$ considered as heavy polluted (Olowoyo, Mugivhisa and Busa, 2015). Measured pollution index for soil heavy metals around the factory were recorded in (Table 3).

Table 3 Pollution index for soil heavy metals

Sample No	Pb	Cd	Ni
1	0.0023	0.0060	0.0012
2	0.0014	0.0050	0.0011
3	0.0007	0.0023	0.0031
4	0.0008	0.0020	0.0085
5	0.0011	0.0060	0.0056
6	0.0014	0.0023	0.0019
7	0.0029	0.0047	0.0065
8	0.0020	0.0040	0.0037
9	0.0004	0.0093	0.0038
10	0.0003	0.0110	0.0023
11	0.0015	0.0097	0.0034
12	0.0019	0.0110	0.0019
13	0.0009	0.0027	0.0018
14	0.0011	0.0153	0.0026
15	0.0007	0.0050	0.0001
16	0.0009	0.0020	0.0005
17	0.0012	0.0027	0.0005

Sample No	Pb	Cd	Ni
18	0.0007	0.0037	0.0008
19	0.0016	0.0037	0.0009
20	0.0010	0.0610	0.0025
21	0.0004	0.0053	0.0001
22	0.0011	0.0040	0.0012
23	0.0004	0.0050	0.0025
24	0.0024	0.0020	0.0005

Source: Asmaa Elrasheed (2022)

Descriptive statistical results for minerals concentration in soil samples around factory are summarized in (Table 4) and correlation coefficients between elements were tabulated in (Table 5).
Table 4 Descriptive statistical results for mineral concentrations around factory

	Na	K	Ni	Cd	Pb
MIN	1.8790	1.9470	0.0100	0.0060	0.0330
MAX	54.8700	33.3800	0.6760	0.1830	0.2940
AVE	10.7123	11.0784	0.18958	0.02325	0.1191
ST	15.2124	9.1120	0.1669	0.0356	0.0704

Source: Asmaa Elrasheed (2022)

Table 5 Correlation coefficients between elements in soil around factory

	Na	K	Ni	Cd	Pb
Na	1				
K	0.0801	1			
Ni	-0.2419	0.0657	1		
Cd	0.5429	-0.1505	0.0327	1	
Pb	-0.1801	-0.3712	0.1181	-0.2276	1

Source: Asmaa Elrasheed (2022)

The positive correlations found between metals could indicate a common source or chemical similarities, whilst the negative correlation could indicate that the metals originated from different sources or different chemical properties as reported by Onwudiegwu, Ezeh and Obioh (2016). A weak positive correlation between Na and K was observed in all results. In general concentrations of heavy metals in the soil around Berber cement factory were found to be rather low. This might be due to the length of operation time of the relatively established factory. This explanation agree with that stated by Olowoyo, Mugivhisa and Busa (2015) and also by Wufem (2014) who postulated that the change of both magnitude of trace metals in soil and of its pH depend on the length of period of deposition of cement dust on it. A multivariate statistical analysis (MANOVA) is applied to examine effect of factors on metal concentrations. The hypothesis testing in analysis is based on a 0.05 significance level. The results of (MANOVA) is tabulated in (Table 6).

Table 6 MANOVA of metal concentrations around factory

Source	df	Sodium		Potassium		Lead		Cadmium		Nickel	
		F	Sig	F	Sig	F	Sig	F	Sig	F	Sig
Distance	2	3.014	0.076	0.093	0.911	0.386	0.685	0.161	0.852	3.688	0.047
Direction	3	11.129	0.000	1.948	0.160	1.475	0.257	3.282	0.046	0.720	0.554
Depth	1	0.667	0.425	3.846	0.066	0.164	0.690	0.101	0.755	0.140	0.713

Source: Asmaa Elrasheed (2022)

According to analysis almost no factor of distance, direction and depth affect metal concentrations significantly, but there are few exceptions have significant effect to some extent.

Conclusion

- Relatively high mean concentrations were shown by Na, K, Ni and Pb in some samples.
- No clear differences were shown by distance, direction and/or depth for minerals distribution or concentrations.
- All minerals availability in soil samples were within the permissible guideline values.

- The mean concentrations of Na, K and Ni were higher than that of control samples.
- The availability means of the hazardous minerals, Pb and Cd were lower than that shown by the control samples.

Recommendations

- Further studies may be needed throughout the River Nile state and specifically the cement production areas including the ore crushing sites.
- Wide range of sampling and different analytical techniques may be required to confirm the best environmental management and safety precautions.
- Periodic scientific assessment should be carried for the different cement factories throughout the country.

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