Analysing effect of cement manufacturing industry on soils and agricultural plants

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Abstract. Today, the study of the effects of dust and gaseous pollutants in the soil as a result of the cement industry, the justification of changes in their properties, the creation of appropriate reclamation technologies is an urgent issue. In the study area, the main source of soil contamination under the influence of the cement industry is dust. The dust mainly spread around the cement plant to a radius of 5,000 meters, causing the soils to become mostly polluted. In the morphological observation of the cross-sections taken by the soil samples, it was mainly influenced by the change in soil colour in the soil surface layer. The chemical and physical properties of the soil change under the influence of pollution, including the tendency to increase the amount of humus as it moves away from the object of study in a wavy pattern. The pH of the soil changed alkalinity. Changes in the agrochemical and other properties of the soil as a result of the cement industry adversely affected the vegetative development of the agricultural plants grown on it, disrupting the growing season and photosynthesis processes and resulting in reduced yields.

1 Introduction

Today, the world's environment, especially soils, is becoming more and more polluted by various industrial enterprises. In particular, during the process of industrial waste, the discovery of natural deposits, the production of construction materials and their use in the national economy, there is a deterioration of agricultural lands and changes in a number of soil properties [1, 2]. Cement is the most widely used raw material in the construction industry worldwide [3]. Historically, the demand for cement in many countries has developed in direct relation to economic growth. As a result of the increase in the world's population, the construction of industries aimed at meeting the demand for housing and daily needs has developed rapidly. This led to the acceleration of cement production, which is the main material in construction. Today, many developing countries are focusing on the rapid development of the cement industry in order to develop infrastructure [1-4]. The average annual amount of cement production per capita on earth is about 1 ton [5].

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Compounds of carbonate-rich chalk, limestone, sand, oxides of CaO, Al_2O_3, SiO_2, Fe_2O_3 are used as the main raw materials in the production of cement. Depending on the method of production and the type of raw material used, cement is divided into several types [6]. The industrial plant located in the study area produces cement. 95% of the cement used worldwide. Cement production requires the following raw materials, mainly using the dry method (Table 1) [7, 8].

Table 1. Chemical composition of dust emitted from a cement kiln.

Chemical substance	Percentage	Chemical substance	Percentage
CaO	49.3	CuO	0.029
SO_3	3.56	Al_2O_3	4.24
SiO_2	17.1	NiO	0.012
BaO (μg/g (ppm))	78.2	Fe_2O_3	2.89
Xlorid	6.90	SrO	0.37
Cr_2O_3	0.011	K_2O	2.18
Zaxarli olov	15.8	TiO_2	0.34
MgO	1.14	V_2O_5	0.013
Na_2O	3.84	ZnO (μg/g (ppm))	65.8
P_2O_5	0.12	ZrO_2	0.011
Alkali (Na_2O+0.658 K_2O)	5.27		

In recent years, industry in Uzbekistan is developing rapidly. The development of the industry is gratifying, of course, because new jobs are being created and it is economically viable, but as a result of the careless use of these industries, the environment is being damaged. As a proof of this, 5-7% of the mixture of CO_2 gases released into the environment under the influence of anthropogenic factors accounts for the share of industry [9]. Globally, various harmful elements are released as a result of industrial pollution. Gas and dust generated by the cement industry are the main environmental pollutants [9-11]. 87-91% of the substances released into the atmosphere during cement production are released into the environment in the form of 9-13% gas in the form of dust (Table 2) [7-9].

Table 2. Chemical composition of gas mixtures formed during cement production.

Chemical substance	Percentage
CO	0.75
CO_2	25.0
SO_2	1.00
O_2	4.50
H_2S	0.15
Chlorine	Trace

These particles and gases are distributed during the processing, grinding, grinding, packaging and delivery of raw materials [9]. The main part of the harmful effects on the environment as a result of the cement industry is the contribution of cement dust, which emits high doses of fluorine, sulfuric acid, hydrochloric acid, lead, zinc, copper and manganese [3]. As a result of the production of 1 kg of cement, 0.07 g of dust is released into the atmosphere [1]. Dust generated during cement production is dispersed by wind for short and long distances, depending on its size [12].

The resulting dusts in the cement production process are dispersed by wind for short and long distances, depending on their size [12]. In addition, Hg, Zn, Pb, Cr and Cd are the sources of heavy metals released into the environment as a result of the activities of many cement plants [10-12] Mercury and cadmium are the most harmful elements released into the environment as a result of the cement industry [13].

The cement production process requires intensive energy consumption, resulting in the release of large amounts of CO_2 into the environment. CO_2 is mainly formed during the extraction of calcium oxide and the processing of calcium raw materials [12, 13]. The mixture of harmful gases released into the atmosphere not only pollutes the atmosphere but also affects human health. Regional and global exposure to harmful gases results in global warming, ozone depletion, acid rain, biodiversity, and crop yields [14]. In addition, production in cement-producing areas has led to a decline in plant growth, reduced productivity and even death [15]. The purpose of this study was to determine the impact of cement industry on soil morphological characteristics, as well as physicochemical and agrochemical properties.

2 Research area and data

Study area is Akhangaron district of Tashkent province, Uzbekistan (lat. lon. 40°58`36``N, 69°40`03``E) (Fig. 1) and its soil is mainly typical sierozem. The relief of these soils develops under different conditions. Irrigated typical sierozem is also morphologically similar to sierozem soils. They have a short cross-section, a carbonate horizon, and are similar to gray soils in terms of chemical and physical properties [4].

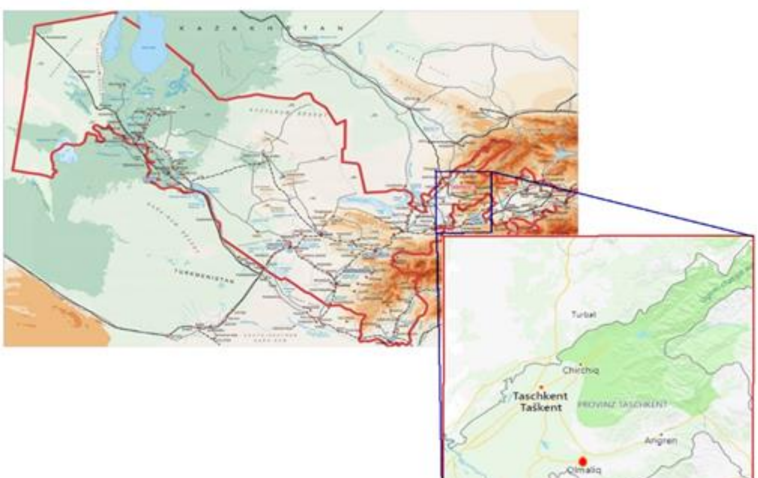

Fig. 1. Research area (Source: GRID-Arendal).

Typical irrigated sierozem soils are washed to a depth of 8 meters, and sierozem-oasis soils up to 15 m, the amount of water-soluble salts does not exceed 0.07%, chlorine is very low - 0.004%. The humus in the topsoil is 1.2% unwashed, 0.913% low wash, 0.86% and 0.55% medium and heavy washed. Mobile phosphorus is 10.8 mg/kg in low-washed soils and 4.7-5.6 mg/kg in medium and strong washes [4-7]. In some places the amount of mobile phosphorus is 36.0 mg/kg, although it is poorly washed. These soils have changed under the influence of irrigated agriculture, the change of which depends on the irrigation period, the intensity and culture of irrigated agriculture [5]. Irrigation of grey soils radically changes their water, air and temperature regimes, as well as the amount of residues falling into the soil, the synthesis and mineralization of organic matter in them, the decomposition and movement of mineral residues [8].

3 Methods

Soil samples were taken from a total of 8 points at a distance of 1 km to 20 km (Sample-1 from 1.5 km, followed by Sample-2 – 2 km, Sample-3 - 3 km, Sample-4 – 5 km, Sample-5 - 7 km, Sample-6 – 12 km, Sample-7 – 14 km, and Sample-8 - 20 km) far from the cement plant from the soils scattered on the agricultural lands around the cement plant. Soil samples were taken from the marked sections to the west of the cement plant. This is due to the fact that the dust and gaseous substances formed as a result of cement production are mainly distributed to the west as a result of the wind factor. To compare the laboratory results and know the exact impact of the cement industry, a soil sample was taken for the background at a distance of approximately 25 km from the cement plant. The experiments were performed under laboratory conditions on the basis of specific methods. In laboratory experiments, different soil properties, the degree of contamination with cement and the influence of various factors were studied. According to him, the following were detected in the laboratory [16-18]:

- Mechanical composition of soil - by the method of N.A. Kachinsky;
- The amount of humus - according to the method of I.V. Tyurin;
- Mobile phosphorus P_2O_5 - Machigin method;
- Exchangeable potassium K_2O-Machigin method;
- Determination of water absorption content was determined on the basis of UzPITI methodical manual;
- pH ISO 10390 (www.iso.org).

4 Results

According to our research, the following can be cited as the main source and factor of pollution of the soils around the studied cement plant under the influence of the cement industry sources are raw material extraction deposit and process and cement production process, Factors are wind, precipitation and anthropogenic. The cement production industry can also be recognized as a hazardous source that plays a major role in significant soil pollution, as land degradation is also found mainly at a distance of 1-1.5 km around cement plants.

It can be seen that man-made degradation and contamination of the soil cover occurs during the process of extraction of raw materials required for cement production from quarries, processing, packaging and delivery. Data shows the gases consisting of a mixture of dust and 5 different gases in 21 different chemical compounds react in the atmosphere and fall to the soil, and their removal from the soil is difficult in the reclamation process.

As mentioned above, the system of raw material extraction and cement industry is the main source of pollution, but there is a difference in the occurrence of pollution. In the pollution that occurs during the extraction of raw materials, the soil cover is damaged by various mineral dusts. In the process of cement production, the soil cover is complexly contaminated, that is, contaminated with heavy metals, salts, sulfides, mechanical compounds and other substances contained in various gases and dust fractions. In contrast to cement production, the scale of pollution around the raw material quarry is wide, and the scale of the contaminated area decreases as it moves away. Wind and rain are less than in the cement industry system. Conversely, gases and dusts generated by cement production are spread from high pipes to areas farther away from the wind, increasing the scale of pollution.

Due to the fact that the pollutants generated during the cement production process come from industrial pipes, the scale of pollution in the vicinity of the industry is small, divided into 6 zones according to the distances and boundaries of pollution (Table 3).

Table 3. Territorial pollution boundaries of soils by sources of pollution.

Zones	Distance from source of pollution (km)
Industrial enterprise protection zone	0.5-0.75
I zone	0.75-1.5
II zone	2-8
III zone	4-15
IV zone	8-20
Control zone	20-50

Territorial pollution of soils by sources of pollution depends mainly on the influencing factors, and the level of pollution also varies in different regions. The main pollutant in the study area is wind, which blows mainly from the cement plant to the west. For this reason, the soil sample cuts were placed to the west.

Contamination of soils with dust generated by the cement industry changes the physical and biological properties and chemical composition of the soil. The degree of change depends on the type of soil, condition and amount of contaminant. The relief and irrigation method of the research object is specific and differs from each other in the study area according to the impact of pollution sources on dry and irrigated soils.

Cement raw material deposits in the system related to cement production, soil contamination is on the surface, especially as a result of the operation of the cement plant belonging to the study area, the soil cover is contaminated on the surface. Depending on the degree of contamination, they affected up to different layers of soil. In this context, the morphological features of the soil varied mainly from top to bottom. The following describes the morphological features of the soil sections belonging to the study area.

Sample-1 cross section. It was excavated 1.5 km east of the Akhangaron Cement Plant. The color is gray but the effect of dust and ash is gray, dry, unstructured, moderately dense, the mechanical composition is medium sand, plant roots are very rare, almost not found in the top layer. Invertebrates do not have nests, tracks, and new creations. Agricultural activities were carried out in and around the area a few years ago but are no longer used. Cement dust and ash residues from coal combustion are found in the sample 0-20 cm layer. Therefore, the physical properties of the soil have also changed dramatically, the density, water permeability properties, structural condition have also suffered greatly at very high levels of pollution (Table 4).

Sample-2 cross section. A second soil sample was taken at a distance of 2 km from the study site. Autumn wheat was planted in the area where the soil sample was taken. The color is gray, dry, lumpy structure, moderately dense, the mechanical composition is medium sand, and plant roots are rare. The top layer of soil and plants have dust in the form of gray (Table 4).

Sample-4 cross section. Soil samples were taken at a distance of 5 km from the study site. The area where the soil sample was taken was previously used in agriculture but has been abandoned for months. The color of the soil is gray, dry, coarse-grained structure, dense, the mechanical composition is medium sand, and plant roots are rare. Small organisms can be seen. In the upper layer of the soil there are dusts in the form of gray (Table 4).

Sample-7 cross section. It was excavated 14 km west of the Akhangaron plant. This main cut was dug in an orchard planted 14 km away. Examination of the flora and fauna of the excavated area revealed that the leaves of the trees were heavily settled by dust generated by the cement industry (Fig. 2) (Table 4).

Fig. 2. Tree leafs on research area side.

Table 4. Changes in the mechanical composition of the soil.

Samples	**Soil layer, cm**	**Particle size, in mm %**								**The name of the soil according to mechanical tracking**
		Sand			**Dust**			**Clay**		
		>0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01	
1	0-20	0.8	0.2	10.6	23.9	-	-	-	64.5	Clay
2	0-20	3.2	0.8	23.5	16.3	-	-	-	56.2	Sandy clay
3	0-20	3.6	0.9	4.6	40.5	-	-	-	50.4	Sandy clay
4	0-20	0.6	0.4	10.1	24.9	-	-	-	63.9	Clay
5	0-20	3.9	0.9	20.1	37.7	-	-	-	37.7	Sandy clay loam
6	0-20	2.8	1.2	24.8	17.3	-	-	-	55.9	Sandy clay
7	0-20	1.9	3.1	22.1	21.6	-	-	-	51.3	Sandy clay
8	0-20	4.1	0.8	18.2	24.6	-	-	-	52.3	Sandy clay

The change in the pH environment of the soils scattered around the cement plant is a chemical process and is the result of the action of chemicals with an acidic environment in the soil (Fig. 3). At the same time, the microbiological world changes and the activity of the enzymes urease, polyphenol oxidase, dehydrogenase decreases. This negatively affects the biochemical processes that take place in the soil.

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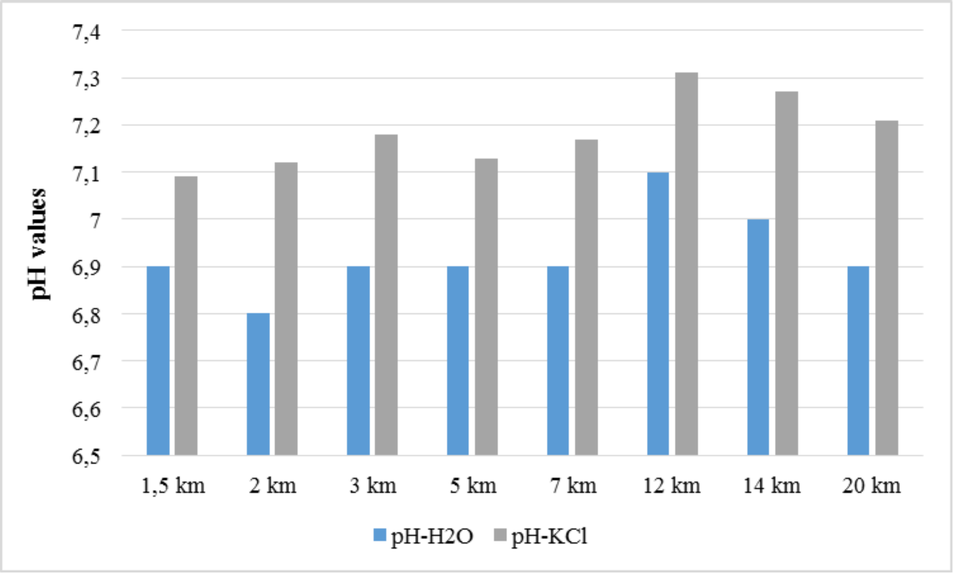

Fig. 3. pH index of soil in research area.

When the results of the analysis obtained in the table above were scientifically correlated with the dependence of pollutants and distances in the form of gas and dust emitted from the cement plant, the result was 0.5019 positive (Fig. 4).

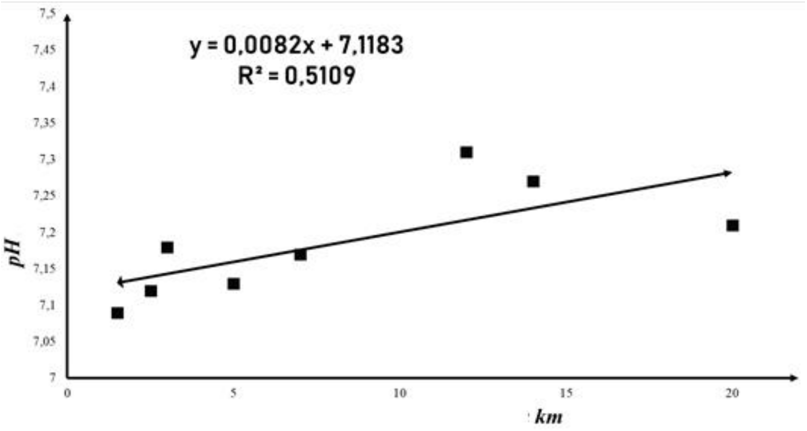

Fig. 4. pH influence of cement industry activity on vegetative development of plants.

5 Discussions

Contamination of the environment with cement dust causes all parts of the ecosystem to become alkaline [1-3]. On this theory, researchers have conducted research and proved that contaminants formed as a result of cement production increase the alkalinity of the soil ecosystem and affect the electronic conductivity, pH and physicochemical properties of soil [4, 5]. In the cement industry, untreated cement particles disperse in a variety of ways, altering the physicochemical and biological diversity of the soil. Scientists have also shown that pollutants in the form of dust have a negative effect on the activity of soil microorganisms, affecting the biogeochemical cycle of nutrients in the soil [6-9]. Cement industry contaminants reduce the microbial population and soil biomass in the soil composition [10]. Enzymes in the soil are an indicator of soil microbial activity [11]. It has been found that the slowdown in plant development as a result of industry, especially the cement industry, leads to a decrease in productivity and even extinction [12]. In particular, dust has a negative effect on physiological processes occurring in plants [13-15]. Researches effects of dust released into the environment as a result of cement production and studies on the effects of vegetation during the growing season have shown that plant length, number of leaves, and plant cover lag behind that of plants grown in conditions free of cement dust.

6 Conclusions

Dust and gases are the main sources of contamination of soils in the study area as a result of the production of cement products. The main wind factor in their spread. The effect of particulate matter contaminants generated in cement production in the study area was mainly influenced by the morphological characteristics of the soil. This is clearly seen in the morphological observation of the cuts taken from the soil samples. Basically this had a greater effect on the change in soil color in the soil surface layer. Soil moisture changes as it moves away from the object of study, i.e., its moisture content increases. The chemical and physical properties of the soil have changed under the influence of pollution, including an increase in the amount of humus, which tends to increase as it moves away from the object of study. As a result of pollution, soil pH and distance are correlated, and soil properties and fertility change as they move away from the study object. The study area is located in the Akhangaron valley of Tashkent province, where the sharp continental climate, average annual precipitation and high average annual temperature require an individual approach to the reclamation process. In the reclamation of soils contaminated with contaminants formed as a result of the cement industry, the phytomeliorative method is more convenient to use than the other method, is secondary harmless, cost-effective and economical.

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