Effect of weathering condition in industrial zone on air and soil pollution and its impact on human health

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Abstract

This study examines the problems of air and soil pollution in industrial zone in Suez Governorate in Egypt. It views the study of the effect of air pollutants and weathering on the environment, soil and air. Photographs, as well as the use of analytical methods were taken to determine the more and less polluted spots supported the characterization of the site. It has been taking measurements of total suspended particles (TSP) and (PM₁₀). Theairpollutants such as (NO_x,SO_x,CO,CO₂, and NH₃) were determined. The determination of windspeed anddirection, relative humidity and temperature were estimated. Accumulatedheavy metalson dust and soil was analyzed by energy dispersive X-Ray (EDX) and atomic absorption spectroscopy in this work. A review on the effect of presented heavy metals on the human health was also added.

Key Word: Weathering condition, air pollution, soil pollution, human health.

1-INTRODUCTION:

The Earth's atmosphere is a mixture of gases and particulate phase substances. The most abundant of these, nitrogen (N₂) and oxygen (O₂), comprise approximately 78% and 21% respectively, of atmospheric mass and volume. A number of trace gases make up the remaining 1%.These include gases present in essentially constant concentrations: N₂, O₂, Ar, Ne, He, Kr, H₂, and Xe. Others vary temporally and specially, these include water vapor (H₂O) , CO₂, CO,CH₄,O₃ , the nitrogen oxides (N₂O, NO , and NO₂) , ammonia , formaldehyde HCHO , sulfur oxide SO₂and SO₃, a number of reduced sulfur compounds (dimethyl sulfide (CH₃)₂S) , CS₂, Carbonyl sulfide COS , hydrogen sulfide and odd hydrogen species hydroxyl radical (OH) , hydroperoxyl radical (HO₂) , and hydrogen peroxide (H₂O₂) . In addition to these gas-phase substances, the atmosphere contains trace quantities of particulate nitrate such as (NO₃⁻), ammonium (NH₄⁺), and sulfate (SO₄²⁻). (*Ehhalt, 1999;Prinn, 2003*).

Harmful substances into the environment have many adverse effects on human health, agricultural productivity and natural ecosystems.Most ofenvironmental pollution is insidious and its harmful effects only become apparent after long periods of exposure.Pollutant chemicals are responsible for many human illnesses: air pollution in particular has man effects on health, ranging from smoke and sulphur dioxide (SO₂) contributing to the occurrence of chronic bronchitis, and nitrogen oxides (NO₃), volatile organic compounds (VOC₃), ozone (O₃) and carbon monoxide (CO) associated with increased incidence of asthma and other disorders.(*WHO, 2000*).

The natural deposition of nitrogen containing atmospheric compounds other than N₂ is much less. The earth itself contains five times more nitrogen than the atmosphere, but weathering of solid rock is a negligible source of biologically active nitrogen by denitrification (reduction of NO₃⁻ to N₂ and to a lesser extent nitrous oxide (N₂O) and ammonia (NH₃). Human activities, both industrial and agricultural, have strongly increased the amount of biologically

active nitrogen compounds, thereby disturbing the natural nitrogen cycle. Various forms of nitrogen pollute the air, mainly nitric oxide (NO , NO_2 and NH_3) as dry deposition, and NO_3^- and NH_4^+ as wet deposition. Another contribution is from occult deposition (fog and clouds). There are many more nitrogen-containing air pollutants, because their contribution to the total nitrogen deposition is supposed to be small or because their concentrations are probably far below effect thresholds. Nitrogen-containing air pollutants can affect vegetation indirectly, via chemical reactions in the atmosphere, or directly after being deposited on vegetation, soil or water. The indirect pathway includes very relevant processes and should be taken into account when evaluating the entire impact of nitrogen-containing air pollutants: NO and NO_2 are precursors for tropospheric ozone (O_3), which acts both as a phytotoxic and a greenhouse gas. Nitrogen oxide (N_2O) is a greenhouse gas and also contributes to the depletion of stratospheric O_3 , (Ehhalt, 1999; Prinn, 2003) resulting in increasing ultraviolet radiation. The direct impact of airborne nitrogen is due to toxic effects, eutrophication and acidification.

In this work, we study the effect of weathering conditions in industrial area in Suez governorate industrial zone on the rate of pollution in air and soil including review on the impact of present heavy metals on the human health.

2- Experimental:

2-1. Location Description:

The selected location for these sites of the work was in the Suez governorate industrial zone. From the west and North West side inside the location, from the preview site, we found the following:-

Pictures have been taken from the area by (Google Earth site) figure (1). The picture showed that:

1- The location from the highest site with surrounding more and less polluted place and arrow shows the trend in emissions fall on the locations. However, figure (1) showed the most polluted area that face the fertilizer factory (Site 2) and bright smoke of nitrogenous compound observed in this area. Also showed the area, which is the less pollution (Site 1).

Figure (1) show the case study location in Suez governorate zone

2. In the northwest direction fertilizer factory:

The factory produces nitrogenous fertilizers, concentrated sulfuric acid, and diluted nitric acid, and produces exhaust gases of nitrogen oxide, sulfur oxides and ammonia graduated from the factory.

3. In the west there is Ataka Mountain who gives big laden storms of particles and dust.

4. In the south east there are stacks of four steam units of power station, which when work by heavy fuel oil, the units will come out of them exhausts combustion processes of nitrogen, sulfur and carbon oxides depending on the type of fuel used.

2-2. Samples taken from the sites:

1. A number of samples were taken from the soil and air of the sites of more polluted place (to the north direction) site 2.
2. Other samples were taken from the less polluted place (to the east direction) Site 1.

2-3. Analysis and instruments:

-Total suspended particles measurements (TSP and PM₁₀) have been taking over long time, and take the average values along day in each of the more polluted place on the north direction and the less polluted place on the east direction. The suspended particles in air were measured by Suspended particles Analyzer TSP (FH62 C14). It can be configured for TSP and PM₁₀ sampling.

- The air pollutants such as NO_x, SO_x, CO₂, CO, NH₃ in each of the more and less polluted place were determined as well as the direction and wind speed, relative humidity and temperature by using:

*Environmental Gas measuring device; Miran-Sapphire-USA.

*Wind speed measuring was detected by Air-Speed meter-USA.

- Analysis of the collected soil from the land of site 1 and site 2, and dust on the filter of (TSP) device in the same sites for the determination of elements composition of soil and dust were measured by energy dispersive X-Ray EDX (Joel -T 200).

-Ion chromatography (IC) was used to analyze the nitrates, sulfates and ammonia on the soil and dust after soaking in deionized water for 4 hours using Ion Chromatographic Analyzer (IC.3000).

-Total Organic Carbons (TOC) was determined by (TOC Analyzer Multi N/CU.VHS) for soil and dust after soaking in deionized water for 4 hours.

-Heavy metals have been measured for the collected soil samples using atomic absorption (SOLAAR 4S) for soil and dust after soaking in deionized water for 4 hours.

- Oils and greases in the soil in each of the more polluted place and less polluted one for soil and dust after soaking in deionized water for 4 hours.

3-Results of tests and measurements:**3-1.Measurement and analysis of ambient air pollutants:****3-1-1.Suspended particles:**

Table (1) shows the measured values for each of the total suspended particles (TSP) and at least 10 microns (PM₁₀) in the period referred to above shall, to the lowest value and the highest value of the medium and the value of these particles.

Table (1) Total suspended particles TSP measurements and at least 10 microns (PM₁₀) in the both sites at more and less polluted area.

Measurement Location	Total suspended particles (TSP) $\mu\text{g}/\text{m}^3$			Particles less than 10 microns (PM ₁₀) $\mu\text{g}/\text{m}^3$		
	lowest value	highest value	Average	lowest value	highest value	Average
Site(2) more polluted	67	388	201	0	289	91.4
Site (1) less polluted	0	301	179.4	0	20	8

The following figures (2, 3, 4 and 5) show measuring amounts of total suspended particles TSP and suspended particles less than 10 microns PM₁₀ changes during the period in the area more and less polluted where adapt from these forms to amounts of these emissions. On the site surrounding environment changes with the times change, so it has been less and greater value as well as the average of these quantities during the measurement period.

Figure (2) Change in total suspended particles (TSP) during period of time in the less polluted location (Site1).

Figure (3) Change in total suspended particles (TSP) during period of time in the more polluted location (Site2).

Figure (4) Change in total suspended particles less than 10 microns (PM_{10}) during period of time in the less polluted location (site1).

Figure

(5) Change in total suspended particles less than 10 microns (PM₁₀) during period of time in the more polluted location (site2).

3-1-2. Air pollutants(gases and ammonia as well as wind speed and direction, relative humidity and temperature):

Table (2) show air pollutants such as carbon dioxide , nitrogen and sulfur oxides and sulfur ammonia as well as the speed and direction of the wind in the region. Results in Table (2) indicate that the atmospheric air pollution gases nitrogen oxides, sulfur oxides and ammonia at the site (2) more polluted area. The source of these gases is fertilizer factory. Also the less polluted site has lowest values of measured parameters and in the location away from wind direction.

Table (2): Analysis of in air of sulfur as well as speed and wind direction, temperature and relative humidity.

Measurement Location	CO ppm	CO ₂ ppm	NO ₂ ppm	SO ₂ ppm	NH ₃ ppm	T°C	H%	Wind direction	Wind speed m/s
Site(2) Less polluted	3.2	395	2.6	1.88	19.5	16-18	65-80	west	7.9
Site(1) More pollution	2.7	380	1.65	1.21	5.5	16-18	65-80	west	22.8

Figure (6) show the image of fertilizer factory and its emission from its stake to the surrounding area.

Figure (6): Fertilizer factory in the industrial zone.

3-1-3. Analysis of dust deposited on the filter of (TSP) device:

The dust deposited on the filter of TSP device during the period of work were collected and analyzed for each of deposited heavy metal, nitrates, sulfates, residual ammonia, total organic carbon, pH and oil and grease. Figure (7) describes the dust deposited on the filter of (TSP) device.

Figure (7): Dust deposited on the filter of the used (TSP) device.

- Analysis of elements in the dust deposited on the filter of (TSP) device by using (EDX).

The Analysis of dust deposited on the filter of (TSP) device using (EDX) in the lowest and highest polluted sites are shown in table (3).

Table (3): Analysis of elements in the dust deposited on the filter of (TSP) device by using (EDX).

Sample Element(%)	Site(1) Less polluted	Site(2) More pollution
O	30.114	40.09
Mg	1.86	32.7
Al	1.12	0.82
Si	12.79	10.79
S	3.72	2.26
Cl	1.02	1.44
K	2.87	1.89
Ca	19.95	24.13
Fe	3.04	2.79
Zn	15.65	8.84
Ba	7.83	4.23

Table (3) shows the type and estimate the proportion of the constituent elements of the dust deposited on the filter of (TSP) device for the two samples of the more and less polluted sites. The highest values of the elements present in the dust collected are:

1. Calcium (Ca) and Silicon (Si) were exported from sandy storm from the mountain of Ataka to the environment surrounding the site.
2. Zinc is likely to be the result of power station equipment corrosion protection layer failures that made from zinc material. Therefore it must examine the equipment's and electricity towers and search for the causes of the presence of this component in the dust for the safety of the protective layer of the equipment's and towers and, most importantly for human health protection.

- Analysis of water of soaking of the dust deposited on the filter of (TSP) device.

To show the effect of polluted dust on the underground water, analysis of the water after soaking the dust deposited on the filter of (TSP) device using ion chromatography (I.C) and total organic carbon (TOC) devices for each of the more and less polluted one were done. The results are listed in table (4&5).

Table (4): Water of soaking analysis (pH, nitrates, sulfates, and residual ammonia) on the filter of (TSP) device.

Test Sample	Max. and min. values	pH	NH₄mg/l	SO₄mg/l	NO₃mg/l
Less polluted site (1)	Min.	7.3	4.7	11.5	8.6
	Max.	7.2	5.6	43	15.6
More polluted site(2)	Min.	7.4	4.8	28	17.9
	Max.	7.6	10.7	22.4	38.3

Table (5) Water of soaking analysis(total organic carbon (TOC),total carbon (TC) and inorganic carbon (IC)) on the filter of (TSP) device.

Test Sample	Max. and min. values	TOC mg/l	TC mg/l	IC mg/l
Less polluted site (1)	Min.	6.85	9.3	2.43
	Max.	8.95	15.7	6.79
More polluted site (2)	Min.	4.05	12.4	8.39
	Max.	12.95	18.8	5.79

3-2. Analysis of soil:

In the previous reason a number of samples were collected from the soil of the more polluted area (Site2) in front of fertilizer company and other samples from the less polluted (site 1) away of fertilizer company and power plant (wind direction). The soil samples are soaked in deionized water for 4 hours to show the effect of polluted soil on the underground water.

Table (7) Show the average values of pH and oil and grease for a number of water of soaking samples of both sites.

Table (7) the average values of pH and oil and grease for a number of water of soaking samples of soil taken from both site1 and 2

Analysis Sample	Soil Sample (site2) More pollution	Soil Sample (site1) Less pollution
pH	7.4	7.3
Oil & Grease (mg/Kg)	706.4	639.6

The soil samples were also analyzed using Atomic Absorption spectrophotometer to estimate contamination of heavy metals (Ni, Cr, Zn, Pb and Cd). The results are shown in Table (8).

Table (8): The results of analyses of heavy metals in the water of soaking of soil samples collected from the more and less polluted sites by using Atomic Absorption**Spectroscopy:**

Sample Analysis(mg/Kg)	Soil Sample (site 2) More pollution	Soil Sample (site 1) Less pollution
Ni	83.24	48.42
Cr	57.73	49.38
Zn	194.5	69.49
Pb	4.17	<0.001
Cd	0.12	<0.001

It can be seen from Table 8 that the zinc element has the highest value presence in the soil samples especially in site 2. This indicate that the source of this element is as a result of the erosion of the protective layer of the equipment's and towers of power plant which can be confirmed from the results of analyses of dust by using X-ray.

3-4.Review on the effect of the present elements (Ni, Cr, Zn,Pb, Cd) in the dust and soil on the site location and its impactson human health:

3-4-1. Effect of the present heavy metals on soil:

Heavy metals are considered as one of the major sources of soil pollution. Heavy metal pollution of the soil is caused by various metals especially Cu, Ni, Cd, Zn, Cr, and Pb(*Hinojosa M.B. et al, 2004*). Heavy metals indirectly affect soil enzymatic activities by shifting the microbial community which synthesizes enzymes (*Shun-hong, 2009*). Heavy metals exhibit toxic effects towards soil biota by affecting key microbial processes and decrease the number and activity of soil microorganisms. Conversely, long-term heavy metal effects can increase bacterial community tolerance as well as the tolerance of fungi such as arbuscularmycorrhizal (AM) fungi, which can play an important role in the restoration of contaminated ecosystems (*Mora A.P. et al , 2005*) . Cd is the more toxic to enzymes than Pb because of its greater mobility and lower affinity for soil colloids. Cu inhibits b-glucosidase activity more than cellulose activity. Pb decreases the activities of urease, catalase, invertase and acid phosphatase significantly. Phosphatase and sulfatase are inhibits by As (V) but that urease was unaffected. Cd contamination has a negative effect on the activities of protease, urease, alkaline phosphatase and arylsulfatase but no significant effect on that of invertase. Chromium is commonly present in soils as Cr (III) and Cr (VI), which are characterized by distinct chemical properties and toxicities. Cr (VI) is a strong oxidizing agent and is highly toxic, whereas Cr (III) is a micronutrient and a non-hazardous species 10 to 100 times less toxic than Cr (VI)(*Garnier J. et al, 2006*). Cr (VI) has been reported to cause shifts in the composition of soil microbial populations, and known to cause detrimental effects on microbial cell metabolism at high concentrations(*Shun-hong H. et al, 2009*).

3-4-2.The impacts of the present heavy metals on human health:

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues(*SobhaK.et.al,2007*). Cadmium (Cd) is a well-known heavy metal toxicant with a specific gravity 8.65 times greater than water. The target organs for Cd toxicity have been identified as liver, placenta, kidneys, lungs, brain and bones (*SobhaK.et.al ,2007*). Depending on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may result in pulmonary odema and death. Pulmonary effects (emphysema and bronchiolitis) and renal effects may occur following subchronic inhalation exposure to cadmium and its compounds(*Duruibe J.O. et.al , 2007*). Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction. The clinical signs of zinc toxicosis have been reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, kidney failure and anemia (*Duruibe J.O. et.al, 2007*). Copper (Cu) is an essential element in mammalian nutrition as a component of metalloenzymes in which it acts as an electron donor or acceptor. Conversely, exposure to high levels of Cu can result in a number of adverse health effects such as Cu intake due to genetic predisposition or disease (*Stern B.R. et.al,2007*). Excessive human intake of Cu may leads to severe mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage and central nervous system irritation followed by depression. Severe gastrointestinal irritation and possible necrotic changes in the liver and kidney can also occur. The effects of Ni exposure vary from skin irritation to damage to the

lungs, nervous system, and mucous membranes (*Argun M.E. et al,2007*). Lead (Pb) is physiological and neurological toxic to humans. Acute Pb poisoning may results in a dysfunction in the kidney, reproduction system, liver and brain resulting in sickness and death (*Odum H.T., 2000*). Chromium (Cr) is the 10th abundant element in the earth's mantle and persists in the environment as either Cr (III) or Cr (VI). Cr (VI) is toxic to plants and animals, being a strong oxidizing agent, corrosive, soluble in alkaline and mildly acidic water, toxic and potential carcinogens (*Shaffer R.E. et al,2001,Jeyasingh J. & Philip L., 2005,Shun-hong et al, 2009*). The toxicity of Cr (VI) derives from its ability to diffuse through cell membranes and oxidize biological molecules (*Shaffer R.E. et al,2001*).

4-Conclusion:

The presents of pollution in the site location due to the industrial activities has bad effect on environment and human health. Evidenced by the results of analyses of polluting gases in the air and soil samples, in addition to the relative humidity, temperature, wind speed and wind direction derived from the proposed site for any establishment revealed that it must be installed any establishment away from the source of pollution with taking into consideration the following parameter:

1. The east side of industrial zone in Suez governorate is the least polluted soil and air.
2. The northwest in the front of fertilizer factory is the most polluted area for either soil or air.
3. The wind direction is to the east in the industrial zone.

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