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Building Site Contaminants: Effects on Building Construction and Prevention Strategy

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Abstract

This paper focuses primarily on building site contaminants and their effects on building construction. Adequate testing of site soil before building construction is inevitable factor for human safety and economic gain. Although the recent attention of people involved in building construction in developing countries in particular Nigeria focuses on how to maximize their profit on construction by skipping one or more process involved such as soil testing. This paper first presents the background information on building site soil contaminants. Further the details of soil contaminants present in many building sites and their sources of existence are elucidated. Some of the major effects of one or more of the contaminants on building construction are illustrated. Finally, the prevention of contamination on building construction via soil testing, remediation and monitoring are illustrated.

Keywords:
Site Soil, Contaminants, Building Construction, Effects, Remediation

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Background to the Study

In recent times more people are involved in building construction which involves getting raw materials, bringing them together in an organized way and then putting them together into a recognizable form. The constructed building slowly decays as it is used and abused by the environment and the owners. Building construction is then definitely not a new science or technology and yet it undergone great changes over its history. The building constructional changes over the years in the developing countries especially in Nigeria has led to building failures/collapses on regular bases (Ezeagu, Udebunu & Obiorah, 2015). Building are constructed on a site without survey design and testing of soil by unqualified contractors and qualified contractors who want to make extra profit.

Further subsurface soil of many building sites worldwide have been contaminated with a wide range of toxic organic compounds, inorganic materials and heavy metals. Most of these soil contaminants affect building materials negatively. Halogenated organic contaminants such as pentachlorophenol, trichloroethylene, trichloroethane, dinitrotoulene and trinitrotoluene are present at several sites, persistent in the environment and effects more than 60% of building materials (Reddy, Khodadoust, & Darko-Kagya, 2008). Majority of people involved in building construction do not take any preventive major against building materials coming in contact with the contaminated site soil as they are ignorant of them or feel that their effects are negligible. It is therefore, necessary at this point to study how site soil contaminants negatively affect building construction and this may be the aim of this study. The aim of this study is to identify and analyze the negative effects of site soil contaminants on building construction and possible ways of preventing them.

Site Soil Contaminants

Soil is contaminated when there is build-up of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents, which have adverse effects on living and non-living things and animal health (Okrent, 1999). Soil can become contaminated through seepage from a landfill, oil drilling, mining and activity, accidental spills, corrosion of underground storage tanks and pipes, acid rain, intensive farming, road debris, discharge of industrial waste into the soil, percolation of contaminated water into the soil, rupture of underground storage tanks, **e**xcess application of pesticides, herbicides or fertilizer, **s**olid waste seepage (Valentın, Nousiainen and Mikkonen, 2013).

The most common materials involved in causing soil contamination are:

Organic compounds such as Petroleum hydrocarbons

Heavy metals such as lead

Inorganic materials such as Pesticides, herbicides, fertilizer etc

Inorganic Toxic Compounds

Inorganic residues in industrial waste cause serious problems as regards their disposal. They contain metals which have high potential for toxicity. Industrial activity also emits large amounts of arsenic fluorides and sulphur dioxide (Richardson, Bright & Dodd, 2006). Fluorides are found in the atmosphere from superphosphate, phosphoric acid, aluminium, steel and ceramic industries. Sulphur dioxide emitted by factories and thermal plants may make soils very acidic. Copper, mercury, cadmium, lead, nickel, arsenic are the elements

which can accumulate in the soil, if they get entry either through sewage, industrial waste or mine washings (Olawoyin, Oyewole, & Grayson, 2012). Some of the fungicides containing copper and mercury also add to soil contamination. Smokes from automobiles contain lead which gets adsorbed by soil particles and is toxic to plants.

Organic Wastes

Organic wastes of various types cause contamination hazards. Organic wastes contain borates, phosphates, detergents in large amounts. The main organic contaminants are phenols and coal. Asbestos, combustible materials, gases like methane, carbon dioxide, hydrogen sulphide, carbon monoxide, sulphur dioxide and petrol are organic wastes. The radioactive materials like uranium, thorium, strontium etc. also cause dangerous soil contamination/pollution. Fallout of strontium mostly remains on the soil and is concentrated in the sediments (Nathanail, McCaffrey, Earl, Forster, Gillett, Ogden & 2005). Other liquids wastes like sewage, sewage sludge, etc. are also important sources of soil problems.

Sewage and Sewage Sludge

Soil contaminants come from uncontrolled disposal of sewage and other liquid wastes resulting from domestic uses of water, industrial wastes containing a variety of contaminants, agricultural effluents from animal husbandry and drainage of irrigation water and urban runoff (Tarazona, Fernandez & Vega, 2005; Evans, Wood & Miller, 2006). Irrigation with sewage water causes profound changes in the irrigated soils. Amongst various changes that are brought about in the soil as an outlet of sewage irrigation include physical changes like leaching, changes in humus content, and porosity etc., chemical changes like soil reaction, base exchange status, salinity, quantity and availability of nutrients like nitrogen, potash, phosphorus, etc. Sewage sludges contaminate the soil by accumulating the metals like lead, nickel, zinc, cadmium, etc.

Heavy Metal Contaminants

Heavy metals are elements having a density greater than five in their elemental form and they are Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Mercury (Hg), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Tin (Sn) and Zinc (Zn) They mostly find specific absorption sites in the soil where they are retained very strongly either on the inorganic or organic colloids. They are widely distributed in the environment, soils, plants, animals and in their tissues. Mainly urban and industrial aerosols, combustion of fuels, liquid and solid from animals and human beings, mining wastes, industrial and agricultural chemicals etc. are contributing heavy metal contamination (Snyder, 2005). Heavy metals are present in all uncontaminated soils as the result of weathering from their parent materials.

Increased doses of fertilizers, pesticides or agricultural chemicals in farms, over a period, add heavy metals to soils which may contaminate them. Certain Phosphate fertilizers frequently contain trace amounts of cadmium which may accumulate in these soils. Likewise, some fertilizers when applied to soils, they add certain heavy metals.

Pesticides

Mercury, cadmium and arsenic are common constituents of pesticides and all these heavy metals are toxic. At present DDT and a number of organochlorine compounds used as pesticides have been declared harmful and banned in U.S.A. and England (Apitz, 2008; Provoost, Cornelis & Swartjes, 2006). It is due to the persistence of their residues in soils for considerable time without losing their toxicity. The rodenticides too add to soil pollution
Soil contaminants are categorized as surface and underground contaminants

Negative Effect of Building Site Contaminants on Building Construction

The effect of site soil contaminants on building construction is based on the negative effects of these contaminants on building materials as shown in table 1.

Table 1 Contaminants and the Effect of Prolong Exposure on Material

Types of material	Contaminant	Effect of prolong exposure on material
Concrete, mortar, concrete blocks	Sulphate & chloride	Loss of strength and stiffness, cracking, stalling and disintegration.
	Acid	Can result in complete disintegration.
	Magnesium and ammonia salt	Most magnesium and ammonium salts cause corrosion and disintegration of concrete.
	Organic compound	Hydrocarbons may deteriorate concrete. Vegetable oils can cause gradual surface degradation.
	Micro-organism Aerobic and anaerobic bacterial	Microbial corrosion of concrete used below ground and lowering PH of soil.
Reinforced concrete	Chlorides, calcium leaching from hardened cement paste	Corrosion of scratched reinforcement concrete bars.
Clay brick	Salt, acid, weather, water	Dissolution of clay brick.
Stainless Steel	Chloride	Slight weakness in film formed when exposed to air and water.
Galvanized steel	Salts and acids	Corrosion
Soil	Organic and inorganic substances	Degradation
Wood	Acid, base, heat, moisture, termites	Loss of strength due to degradation may lead to breakage.

Foundation

Building foundations are laid using concrete blocks and mortar. Sulfate (Tian & Cohen, 2000) and chloride contaminants attack hydrated cement compounds in concrete causing concrete expansion. This leads to loss of strength and stiffness, cracking, stalling and eventual disintegration of concrete (Wanga, Nelsena & Nixo, 2005). In the same vain acid from acidic solutions attack concrete (concrete is an alkaline material) causing complete disintegration. Sulfuric acid and hydrochloric acid are regarded as being aggressive to concrete. Magnesium salt (Amin, Jamaludin, Pa & Chuen, 2008) and ammonium salts attack concrete causing corrosion of concrete from cation-exchange reactions (Magdy & Waleed, 2013). Cement loses binding power and eventually causes disintegration of concrete. Magnesium hydrogen carbonate is an exception.

Organic compound such as hydrocarbons do not attack concrete but are capable of permeating even dense concrete due to concentration of aggressive compounds in them and rate of ingress of hydrocarbon (Wilson, Langdon & Walden, 2001). Vegetable oil can cause gradual surface degradation of concrete.

Micro-organisms such as bacteria can cause microbial corrosion of concrete used below ground (as in foundation) and lower PH or soil (Kawai, Morinaga & Tasawa, 2000). The combined action of aerobic and anaerobic bacteria can result in formation of sulfuric acid that is highly corrosive towards concrete.

The foundation of a building is therefore negatively affected by contaminants such as salts, acids, organic compounds and micro-organisms. Corrosion caused by bacteria or degradation caused by organic compounds or disintegration caused by salts and acids makes building have low structural integrity (ability of a structure or a component to withstand a designed service load, resisting structural failure, and deformation or fatigue) and therefore liable to fail or collapse.

Pillars and Beams

Beams and columns (pillars) or reinforced concrete are being affected by chlorides as calcium leaching from hardened cement paste reduces PH of concrete due to carbonation (Yunping & Patricia, 2000). Scratched reinforcement bars in the concrete corrodes and long term corrosion of reinforcement bars leads to loss of strength of bars and may eventually cause failure. Again salts, acids, organic compounds and micro-organisms also cause reinforced concrete to fail as they affect concretes.

Roof

Acid, base, heat, moisture and termites affect wood used for roofing, doors windows, and frames. These contaminants cause wood to lose strength due to degradation and may lead to breakage. Breakage of roof wood cause sagging of roof and failure.

Other Parts of Building

Loss of strength of concrete in general as a result of contaminants may cause walls deck/floor to fail and these may lead to building collapse. Disintegration of concrete and breakage of wood as a result of soil contaminates will cause a reduction in over all beauty of a building as structural defects will be visible.

Again copper pipes used for gas and water supplies are corroded by acid, sulfates chlorides and ground containing cinders (Jonsson, 2010). In the same vain plastic pipes, membranes and textiles for damp proof courses, cover system and liners deteriorate due to degradation or polymeric constituents or plastic as a result of sunlight, heat, moisture, acids and solvents (Wafia, Latifa & Kamel, 2015). Deterioration of copper and plastic pipes, membranes and textile will cause reduction in the beauty of building.

Prevention Strategy
The study shows that many contaminants exist in building site soil and they negatively affect building materials and building construction and hence the need for prevention or elimination of the soil contaminants in building site.

Preservation of Building Materials
Protection of building materials against contaminants by keeping them in building a where sun, rain/moisture nor site soil touches them.

Soil Testing
Testing of sites soils before designing and constructing buildings.

Remediation
In case of building site soil contaminated with one or more of the contaminants described herein, remediation is recommended. Remediation technologies used will be based on the phase or medium on which the contaminants are found.

Nanotechnology is best used for remediating dehalogenated organic contaminants such as pentachlorophenol and dinitrotoluene by injection of nanoscale iron particles (NIP)in soil on which they are found. Pentachlorophenol (PCP) and 2,4-dinitrotoluene (2,4-DNT) in contaminants can be remediated using NIP and lactate-modified NIP Remediation of other contaminants such as petroleum hydrocarbons, inorganic contaminants and heavy metals, may involve one of biodegradation, bioventing, biopiles land treatment, soil venting, soil flushing, soil washing, coal tar agglomeration, chemical oxidation/reduction, solvent extraction, verification, thermal desorption, solidification, capping and land disposal or land filling.

Monitoring
The main objective of soil monitoring is to prevent and mitigate contamination by substances with the potential to exert an adverse effect on the soil itself, and on air, water and organisms that may contact the soil. Soil monitoring, within the approvals program, is directed primarily to the assessment of contaminants that have been released to the soil surface.
Regular testing of site soil, air and underground water from nearby borehole and comparing the results obtained with standards for environmental protection.

Conclusion
The study on the negative effects of building site soil contaminants on building construction has been successfully carried out. The results showed that soil contaminants such as halogenated hydrocarbons, acids, salts, microorganisms, heat, moisture and termites are present in many subsurface building site soils. The results also showed that the identified soil contaminants affect building materials thereby leading to failure of columns, foundation, beams, slabs, walls and roof. The overall beauty of a building is reduced by failure of copper and plastic pipes, wood, plastic membranes and textiles for damp proof courses, cover systems and liners. Finally, the long term effect of the soil contaminants on constructed buildings is failure or collapse.

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