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An overview of soil and dust fixation

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A R T I C l E I N F O

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A B S T R A C T

Dust storms are common climatic phenomena in arid and semi-arid regions. In Iran, one of the environmental concerns is increasing dust storms. There are several ways to control this phenomenon, each of which has its limitations. Conventional methods for reducing dust storms (especially in arid and semi-arid areas) have been the stabilization of the dust generating center using chemical polymers and petroleum products, which in the current situation, due to the high cost and disagreement about the effects on their environment is not cost-effective. Therefore, due to the problems of this type of soil cover, the use of biopolymers, bio-mulch, and organisms to stabilize dust in recent years has been recommended as a suitable alternative. Biopolymers form a continuous or partially structured structure with each other by forming granulation soils, bonding fine particles together, and forming larger particles. The purpose of this article is to investigate the stabilization of soil and dust by biologically and environmentally friendly and safe methods.

Introduction

In recent years, there has been an increase in successive dust storms around the world, among which, a group caused by the interventions of atmospheric factors and elements, have caused many human and financial losses in different regions. Dust storms have a high frequency in some parts of the world, especially in the Middle East. In the past decade, the occurrence of dust storms in this area has increased as much as they have been observed in the cold and rainy months of this area. Among the countries of Iraq, Sudan, the Arabian Peninsula, and the Persian Gulf region, the most frequent occurrence of these storms has been reported. The spread of this phenomenon and the influence of several countries has caused the attention of scientific, environmental, medical, and even political associations to this phenomenon (Shakouhi and Karimi 2012). Fine particles have a higher frequency in arid and semi-arid regions of the world. Dus can be a kind of reaction to changes in land cover, in this regard; the role of human activities along with the natural conditions of geographical environments should be considered (Arimoto, 2000).

Iran, with an area of more than 164 million hectares, is located at latitude 22 to 42 degrees north, which is located in the dry strip of the earth (Shahsavani, 2010). Inside the country, the movement of quicksands from neighboring countries also causes irregularities in the country's climate system. Currently, wind erosion and the influx of quicksands into economic facilities and biological resources are one of the main problems in the country (Kurdovani, 2001).

One of the problems that have recently been spreading due to human intervention and the irrational use of natural resources and their destruction is the phenomenon of dust. Arid areas, with more than 42% of the earth's surface, are an important source of gradual dust storms (Dehkordi and Huh Abu Nasr, 2015). On a global scale, the risk of wind erosion is lower than that of water erosion, but sometimes it is larger than water erosion (Refahi, 2013).

In recent years, the rate of wind erosion in some parts of Iran has increased significantly and the area affected by erosion is over 32 million hectares, ie about one-sixth of the total area of Iran (Rashinho, 2009). About 12 million hectares of these 32 million hectares are covered by areas with severe erosion susceptibility that require control and protection operations.

Wind erosion control is performed in three steps the stages particle extraction, particle transport, and particle deposition (Armbrust and Dickerson, 1971). For the solution, the best control of wind erosion is in the particle collection stage and the particle transfer stage is the most difficult. In Iran, control is more common in the particle deposition stage (Ahmadi and Heydari, 2010). There are two basic methods for controlling wind erosion, which is: a) reducing the wind speed near the ground to less than the erosion threshold speed, and b) controlling factors affecting soil properties, such as soil moisture (Refahi, 2013). There are several strategies to prevent wind erosion of the soil, the most important of which are as follows: 1) to maintain soil moisture, 2) to establish the vegetation, 3) to create barriers in the winding path, 4) to create coarse-grained soil in surface soil and 5) Mulching.

The most common method of stabilizing quicksands is mulching (Ebrahimi and Shafabakhsh, 2008). Mulch spraying is a natural or synthetic material that can provide a protective, wide layer on the ground and protect the soil surface from various damages such as wind and rain (Skidmore and Fryrear 1985). Mulches are divided into various oil, chemical, and biological groups and must be selected in such a way that they have the desired properties depending on the environmental conditions.

The most important features in the selection of mulches include the following; To have the property of elasticity so that wind and particles cannot scale it, pass the climate and make it available to the plant, have more durability, do not reduce nutrients and do not destroy soil organisms and It has no adverse effects on products and is not harmful to people who deal with it (Josheph et al, 1980). Oil mulches, despite their good performance in controlling wind erosion, have disadvantages that have led to the use of environmentally friendly mulches as substitutes (Santoni et al., 2003). The most important disadvantages of oil mulch are the following (Vaezi 2011): 1) It is blown by the wind and scattered in the environment and causes environmental pollution and creates problems in the growth and development of plants and the health of humans and animals, 2) due to Dark colors have a high absorption coefficient and destroy the energy balance of the environment and cause wind in the place, 3) groundwater pollution and 4) flammable.

For the past half-century, various materials have been used to stabilize quicksands to control wind erosion (Lyles et al., 1974) With the discovery of oil, the use of oil mulch to stabilize fine dust became common. In Iran, oil mulch has been used to control wind erosion for about 42 years, but this mulch reduces the growth of buds by increasing the soil surface temperature and hurts plant living tissues (Rezaei, 2012).

Steel slag controls wind erosion with increasing roughness (Babakhani and Karim Zadeh, 2013). Pebble mulches are also used to inhibit wind erosion. These mulches also trap wind-blown particles (Yanli 2003). Organic mulches such as sugarcane waste increase shear strength, retain moisture, and increase nutrients in the subsoil (Jamili, 2013). Clay mulches are resistant to the wind but are eroded by the simultaneous effect of wind and fine particles (Majdi et al, 2006). Mineral mulch is also used in countries such as the United States and Canada to control dust (Goodrich et al, 2009). From 1980 onwards, soil stabilization with polymer became more important than older stabilizers due to its ease of implementation, speed of application, and high strength (Abbasi et al., 2011). Due to their different properties, these chemicals have been used for different purposes and forms to increase soil storage capacity and control wind and water erosion (Samaee et al., 2007). Each of these polymers is prepared in emulsion, liquid, or solid powder types.

Methods of prevention and control of dust storms

Biological activities

This is one of the key solutions to overcoming dust storms. An example of such an action is the creation of vegetation cover in desert areas. Other measures include controlling the exploitation of trees and forests and preventing the felling of trees and developing ecological barriers such as forest belts that hinder desert development. We can also mention issues such as limiting the expansion of agricultural lands in forested areas and implementing management programs to reduce people's dependence on forests (Refahi, 2010).

Mechanical actions

These include the use of coatings and modifiers to stabilize dunes. In order to improve the soil, change its physical properties and increase its water holding capacity, many different materials are added to the soil. These include plants such as peat (turbia), sawdust, wood chips, leaves, minerals such as bentonite, kaolin, diatomite, gypsum, peat, perlite, lyca, zeolite, and organic materials such as synthetic mulch and polymers. Polymers and zoo planets are among the newest soil remediation materials that have more quantitative and qualitative effects and are widely used (Rah-e-Shahr International Group). Synthetic materials, such as polymeric polyethylene coatings, are also used in parts of the United States (Butler et al., 1771).

Chemical methods

In Iran, petroleum waste (mulching) is used to stop further hill movement. In China, chemicals and plastic mulches are used in arid areas. Chemical methods are harmful to the environment; groundwater causes soil degradation, although this method is effective in controlling sand (Refahi, 2000).

Microbial enzymes (bio enzymes) as soil stabilizers

Enzymes are the catalysts of biological systems that not only control the rate of reactions but can also reduce the activation energy to form a product from another product by preferring certain geometries in the transition state (Scholen,1995). Biovans are protein molecules that catalyze chemical reactions in the soil to form a cementitious bond that stabilizes soil structure and reduces soil-to-water affinity (Tingle et al., 2007). The idea of using enzymatic stabilization for soil pavement came from the use of enzymatic products used for soil treatment to improve horticultural applications (Taha et al., 2013). The process modification produced a suitable material for stabilizing weak ground for road traffic.

As long as there are minimal particles of clay, bio enzymes work on a variety of soils (Kestler, 2009; Khan et al., 2015). According to Khan and Taha (2015), enzymes may work for soils with 12 to 24% clay fraction with a plasticity index between 8 and 35. Enzymatic emulsions perform well when applied at low application rates to the surface of non-conservative roads for dust control (Lim, 2014). At higher application rates, enzyme emulsions can be used to stabilize unpaved roads, paths, and shoulders, access roads, unpaved and unpaved car parks, orchards and roadways, mine transport routes, access roads, small parking lots, airports, rural areas, airports. , Property crossings, and where you need to improve the engineering properties of roadbed materials (ALBC, 2014). When applied and compacted properly, the treated soils can be stabilized to form a dense, hard, water-resistant, water-resistant layer that can be used as a road surface.

Comparison of stabilizers

Traditional stabilizers, such as cement and lime, are relatively expensive, costing up to three times the cost of bio enzymes in some areas, and increase when they have to travel long distances to low-volume road construction sites (Visser, 2007). On the other hand, bio enzymes are usually sold as concentrated liquids, diluted with water at the construction site, and then spread on the soil before compaction or injected under pressure to treat deeper soil layers (Katz et al., 2001).

Due to this, transportation is possible at a relatively reduced price. Because of the lower transportation costs, concentrated bio enzymes can be an attractive alternative to stabilization projects. As a result, unlike traditional soil stabilization methods, bio enzymes are the cheapest, non-toxic, environmentally friendly, and organic technology.

As a result, more attention has recently been paid to the use of bio enzymes as soil stabilizers. This is due to the increased production capacity, low cost, and relatively wide application of enzymes compared to standard stabilizers, which require large amounts of stabilizers to stabilize the soil, which in turn increases the cost of fabrication.

Mechanism of soil bio enzyme fixation

The first proposed stabilization mechanism explained that the enzymes present in the treated soil are absorbed by the clay lattice and in tur,n the cations are released as free exchange, a process similar to cation exchange. This leads to a reduction in the thickness of the dispersed dual layer of clay (Velasquez et al., 2005), Schulen, 1995 (Tingle et al., 2007). Another accepted hypothesis is the mechanism of soil bio enzyme stabilization by Schulen (1995). Schulen suggested that when bio enzyme formulations are mixed with soil, enzymes combine with large organic molecules in the soil solution to produce a reactive intermediate. Large organic molecules have large flat structures that are close to the size of small clay particles that can coat the clay minerals and neutralize the negative charge, reducing the clay's tendency to moisture. As a result, it creates a coating effect that prevents more water uptake and density reduction. This reaction rebuilds the enzymes and helps keep the process going.

Several researchers have shown the formation of stable clay reticulate structures and a reduction in the tendency to moisture after treatment with various bio-enzymatic formulations. Rowach et al. (2003) confirmed, through various chemical and physical experiments, the hypothesis proposed by Schulen (1995) that enzymes bind to large organic molecules and attach to clay surfaces, thus blocking potential cation exchange sites. In addition, prevent moisture absorption and next inflation. In addition, in separate studies by Santoni et al. (2002), Tingle et al. (2007) and Tingel and Santoni (2003) reported a series of laboratory experiments with various bio-enzymatic stabilizers that evaluated the effects of performance in terms of increasing the strength of granular and fine-grained substrates. However, these experiments only classified the proposed stabilization mechanisms as mechanical bonds or chemical reaction mechanisms without detailing the proposed physicochemical changes.

However, Lindenbaum (2008), Rauch et al. (2003), Stan and Chiubano (2012), and John et al. (2013) suggested that the soil suitable for biomass stabilization should contain chemicals such as clay minerals that may react with other chemicals. They showed that enzymes are only suitable for use with clay materials that have a mixed affinity for water, especially high-plasticity clay with organic content. Therefore, substances such as silt and granular soils do not have a significant affinity for water and will be unsuitable for stabilization with enzymatic products (Tingle et al., 2007). In addition, the literature suggests that the use of enzymes is highly dependent on environmental conditions and may occur over a considerable period of time (Tingel et al., 2007; Rajuria, 2014). Rowach et al. (2003) confirmed, through various chemical and physical experiments, the hypothesis proposed by Schulen (1995) that enzymes bind to large organic molecules and adhere to clay surfaces, thus blocking potential cation exchange sites and preventing further moisture absorption and swelling.

Lindenbaum (2008) in his patent publication described a mechanism by which bivanzyme decomposes the dual electrical layer between clay and static (adsorbed) water during soil stabilization. In this way, the clay particles lose their inherent charge and lose the sticky static water layer. In this mechanism, the clay particles are separated and crystallographically fixed to prevent any further volume change in the presence of water. He added: "Organic cations from the growth of vegetation and microorganisms will be able to exchange positions with other ions adsorbed to clay platelets in the soil." Unlike metal cations, organic cations have large flat structures that are close to the size of fine particles of clay. These organic cations can coat the clay particles and neutralize their negative charge in a short distance, thus greatly reducing the thickness of the dual-layer (Tingle et al., 2007). Lindenbaum (2008) also explained that the reduction of the dipole moment of the water molecule by the enzyme leads to the separation of hydroxyl (-) and hydrogen (+) ions. This clears the water molecules of the intermolecular spaces of the clay minerals.

Outlook for Soil Stabilizing Enzymes

Soil biochemical stabilization is now gaining tremendous status and is globally approved by institutions such as WHO and UNESCO. The main feature of soil bioenzymatic stabilization is that it does not use external stabilizing materials. This aspect opens up a great opportunity to improve the soil stabilization process by reducing the cost-effectiveness of the overall process. Due to its enormous economic impact and non-toxicity to the environment, bivanesium is the most promising key for developing countries. Bio enzyme technology is good for any country because it saves time, energy, and money. A better understanding of this emerging technology is crucial to taking advantage of any advances it can make to improve our well-being and the environment around us. Finally, it is believed that the relevant inventions should be identified and commercialized to meet the needs of soil consolidation.

Conclusions

Soil stabilization is a very critical method in any shrinkage project and requires sophisticated technology that provides a solid foundation that can carry traffic loads. The higher cost of chemical and mechanical stabilization techniques has created the need for safe, cheap and easy soil stabilization techniques. For this reason, local production of bio enzymes is the best choice in which cost-effective technologies are the main benefits to the economy. Enzymes have been used as soil stabilizers to improve the strength of substrates due to their low cost and relatively wide application compared to standard stabilizers.

Conflict of interest

The authors declare that they have no conflict of interest.

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