Asian Journal of Water, Environment and Pollution, Vol. 15, No. 2 (2018), pp. 89–98.
DOI 10.3233/AJW-180021

Transfer of Technical Knowledge from Dust Control in Khuzestan Province for Elimination of Hamoon Jazmoorian Wetland Challenges

Zahra Fakhroueian*, Mohammad Ali Attarnejad[1], Pouriya Esmaeilzadeh[2], Farshad Forouzanfard[3], Elham Khaksar[4] and Ali Karampour[5]

School of Chemical Engineering, College of Engineering, and IPE, University of Tehran, Tehran, Iran
[1]University of Munich, Tehran, Iran
[2]Chemical Engineering College, Iran University of Science and Technology (IUST), Tehran, Iran
[3]Jondi Shapur University of Technology, Dezful, Ahvaz, Iran
[4]Environmental Protection Agency, Khuzestan Province, Ahvaz, Iran
[5]Khuzestan Province Governor, Ahvaz, Iran
✉ fakhroueian@ut.ac.ir

Received September 6, 2017; revised and accepted December 19, 2017

Abstract: Hamoon Jazmoorian wetland, which is positioned at the border of Kerman and Sistan-Baluchistan provinces in Iran, consists of three major types of soils including argillaceous silt, swampy types and various clay and sand layers. Given this information and some valuable experience earned in 2-3 years from research on 14 dust focal centres of Khuzestan province, the dust polluted sky of the province and its borders with neighbouring countries, it was attempted to repress the dried Jazmoorian wetland. Hamoon Jazmoorian wetland and the dust regions similar in terms of soil type in Khuzestan such as Hendijan Hur, Saheb Abad of Gharganeh, Dehno in Hendijan, north Azadegan field in Hoveyzeh wetland of Hour-al-Azim and Ashareh-ye Omidiyeh can be converted to alive, healthy and fruitful soil instead of dead, withered and sere ones.

In this study, some healthy and eco-friendly water-based green biological fluid formulations have been prepared for single soils and simulated mixture of the Jazmoorian wetland. Stability tests, mechanical and ecological stabilization of soil-fluid using wind tunnel with 90-100 km/h velocity and also planting vegetable seeds have been completely carried out in lab scale. The performance of biological fluids (green mulch) were very successful. The results of this work can be further developed to industrial and pilot plant scales. All the materials in green biological fluids are very safe and healthy for humans and the environment, without any toxic substance.

Key words: Hamoon Jazmoorian wetland, green biological mulch, soil simulation, ecological soil stabilization, dust focal centres.

Introduction

Wetlands are areas possessing the characterization of both land and water. Wetlands may always be full of water or dry and are occasionally wet. The conditions of some wetlands near the sea change with tides. The main characteristic of wetlands is the relative retention of water. The water of wetlands may be salty or sweet. Ramsar convention is an international treaty, signed in 1971 in order to preserve wetlands. This convention also provides a list of the world's wetlands, which is known as Ramsar list. In the list, Great Britain with 164

*Corresponding Author

wetlands and Canada with 130,000 km^2 of wetlands, have records in terms of quantity and expansion, respectively. The convention permanent headquarter is located in Gland, Switzerland.

Pollution of wetlands in Iran has been criticized by many environmentalists in this country. Lack of waste and sewage management in wetlands, fragment of wetlands, burning the oil basins in wetlands and discharging the waste oil of Azadegan oil field in the wetland of Hour al-Azim in Hoveyzeh, lack of rehabilitation programmes and many other issues have been great concerns of environmental activists. Recently, during two years of volunteerism and continuous researches for battling against the tough challenge of dust phenomenon in Khuzestan province, we managed to stabilize the soil using formulations consisting of numerous natural fluids.

In this regard, with the cooperation of provincial environment department and disaster management organization of Khuzestan province, by recognizing the dust focal centres of Ahvaz city and studying 14 regions responsible for creation of dust in the province, we managed to test the dust suppression using a wind tunnel with 90-100 km/h velocity. Since the restoration of dried wetlands is an important step to fight dust and the dried part of Jazmoorian wetland is responsible for 25% of fine dust production in Iran, reviving the wetland will resolve problems of fine dust in south of Kerman province. On the other hand, due to the intense pollution of Sistan-Baluchistan province and the permanent presence of dust in the mentioned provinces, which seriously endanger the health of inhabitants, it was decided to use the results regarding the consolidation of Khuzestan province dust in the suppression of fine dust in the international Jazmoorian wetland and thus contribute to the improvement of the desertification and climate challenges of this area, which is the habitat of 264 delicious and classy plant species. International Hamoon Jazmoorian wetlands are located between the provinces of Kerman and Sistan-Baluchistan. Hamoon Jazmoorian is located between the mountains of the Makran and Shahsavaran or between the Jebal-Barez mountains in the north and the Webshagard in the south. The name Jazmoorian has been drawn from the dominant vegetation in the southern province of Baluchistan called Jaz in the local dialect among the people. The multitude of Jaz in the area is also called Moorian (Hamoun wetland current situation; Panahi et al., 2005) and Helil-Rud and Bampor rivers join the Hamoon Jazmoorian.

The Hamoon Jazmoorian soil is not very salty. It contains some sweet water, rubble, and layers of sand and lime. The area of Hamoon Jazmoorian in the rainy seasons is 3300 km^2 and most of the rain water converts to saltpan and clay due to the specific climatic conditions. It is also known as one of the most important water resources in the Kerman province. Krynsly divided the area of Hamoon Jazmoorian into three parts in 1970: the seasonal lake with large changes in dry and wet seasons, wet area and the swampy areas, which cover 59% of the wet region. The upper border of the zone stretches to the silt-clay areas, the fine dust of which has recently affected the lives of 15 million people living in Kerman, Sistan and Baluchestan and Yazd.

In this regard, the General Director of the Environment Department of Kerman province, Mr. Mahmoud Safarzadeh, in an interview with the Jam-e-Jam newspaper in March 2016, stated that while the share of Khuzestan province from the fine dust in Iran is 5.4%, Jazmoorian receives about 25% of dusts in the country and ranks first in the country. When the salt marshes of wetland become larger, a mass of elements and compounds in the air will spread by the wind. In addition to degradation of soil and crops, the dust seriously threatens the public health and human life (Yana et al., 2017).

The fine dust not only causes respiratory diseases and eye and gastrointestinal allergies, but also causes many social and economic losses. For example, it may increase the migration of local people to other regions and lead to problems such as unemployment, income reduction, tourism reduction, filling of hospitals with sick children and other people, the exodus of migratory birds and the creation of salt hurricane centres. In this regard, a conference paper has already been presented about the successful stabilization of eight focal points of desert field soils of Khuzestan province using new nano and micro fluids with stable water-based formulations in March 2016 in Ahvaz (Fakhroueian et al., 2016). These nanofluids of high specific surface area were able to adsorb and diffuse into the surface soil layers due to their great reactivity and mobility in soil (Rusul et al., 2016). In order to restore and rescue Jazmoorian wetland from soil erosion and prevent the spread of fine dust with a diameter of less than 5.2 microns, it was decided to use the experimental results and methods implemented to deal with dust of Khuzestan province; especially in the vicinity of Ahvaz. Therefore, the types of the soils lifted from the Hamoon Jazmoorian wetland

were studied and compared with soils of Khuzestan province. A mixture of soils, such as silt-clay soils similar to Hendijan and Omidiyeh, swampy silt and sandy soils similar to Hour-al-Azim of Hoveyzeh and clays similar to five different points in Hendijan, was simulated, fabricated and then treated with new water-based formulations of natural fluids produced in our laboratory (Tripathi et al., 2007; Bahari et al., 2010).

To test the stabilization of soil-fluid, the formulated trays were subjected to a wind tunnel at a velocity of 90-100 km/h for 15 to 20 min. Before and after the blowing process, some pictures were taken by a digital camera with a resolution of 23 megapixels. The results obtained in this part of the experimental work were very successful and we hope to observe similar success in the semi-industrial pilot as well (Section IV: Dust control and stabilization, 2003; Spraying System Co., 2008; Guidance for temporary soil stabilization, 2003). By applying the modern knowledge of fluid fabrication in water base, synthesis of formulations based on soil types, and using environmentally harmless, cheap and favourable materials or solvents, it can be possible to fight this hazardous problem very well. Interestingly, the new formulations of ecofriendly fluids behaved very well in terms of agricultural promotion and planted seeds, such as organic products, green beans, corn and various other vegetables, which can have serious impacts on mitigating air pollution (Sharma et al., 2017; Rafia et al., 2006).

Materials and Methods

This section is divided into five main parts. Initially, the types and qualities of soils are studied. In the second part, the soils of Hamoon Jazmoorian are simulated. The third section is about treating the simulated soils of Hamoon Jazmoorian wetland with synthesized fluids. Part four is related to the mechanical stability tests of the soils soaked with formulated fluids using a strong wind tunnel with 90-100 km/h velocity. The fifth part sums up the performance of green fluid towards stabilization of the soil with images. Finally at the end of this paper, the discussion, conclusions and explanations are given.

1. Type of the Main Soil Used for Hamoon Jazmoorian Wetland

Most type of these soils are of silt-argillaceous structure. Marsh species are similar to Hour-al-Azim of Hoveyzeh and sandy clay layers. Therefore, these soils are similar in structure to those in Ashareh area in Omidiyeh, Hour-al-Azim in Hoveyzeh and six various zones in Hendijan including Bahregan, Saheb Abad and Dehno. Using the information and the results for these soils, the dust of Hamoon Jazmoorian wetland can be suppressed.

2. Simulation of the Hamoon Jazmoorian Wetland Soils

This section contains three individual parts.

(i) The first sample includes a mixture of soils meant to be well compatible with Hamoon Jazmoorian wetland. This mixture includes the soils of Gharganeh+Bahregan+Ashareh in Hendijan and sands of Lakehidar in Shoush. 100 gr of each soil was mixed well in a shaker and then used as an ideal simulated soil similar to Hamoon Jazmoorian wetland in future tests.

(ii) The second soil is a mixture of silt and sand of swampy areas of Hour-al-Azim of Hoveyzeh, silt and clay of Ashareh of Omidiyeh and the clay of Saheb Abad of Hendijan, which is simulated as a sample of the soil mixtures of Hamoon Jazmoorian wetland.

(iii) The third simulated sample is a mixture of various types such as silt of Gharganeh Hour of Hendijan, which contains clay, sand of Farhan Kebr of Shoush (ancient city) and silt and sand of Azadegan field in Hour-al-Azim of Hoveyzeh.

3. Preparation of Novel Green, Water-based and Ecofriendly Fluid Formulation

In this study, many green organic materials water-based, smart ecofriendly and stable water-based fluids have been synthesized and formulated for Hamoon Jazmoorian wetland for the first time in study. The results have been patented by University of Tehran, department of Environmental Protection Agency in Ahvaz, and governor crisis management of Khuzestan province. Hence, the components of the formulation may not be completely revealed. However, minerals, various Na, K-zeolites, the adhesive materials with soil, water soluble wetting agents, dispersants, emulsifiers, softeners, the lubricant particles in solution and green solvents may be pointed out as different components of the formulation. No aromatic and paraffinic solvent and hazardous materials were used in formulations. In addition, these green fluids also contain many nanoporous structures with highly active and energetic surface areas such as nanosensor versus dust emission in the air. They were made to remove air pollution and dust of Hamoon Jazmoorian wetland. Particularly,

the base of the formulations are water soluble natural materials from Iranian mines.

To fabricate water-based formulations, which can be sprayed, some factors must be taken into account, namely, adhesion of the content of fluids to soil, strengthening and improving the soil properties, wettability, dispersion of particles, the ability stability of the particles dispersed in solution and homogeneity by using a suitable emulsifier. Therefore, the fluids were formulated successfully, applied exclusively for the selected soil and all the precautions were taken for mixing them with the soils. The procedure for conducting necessary tests is as follows. Firstly, a certain amount of soil on a large tray with dimensions of 40 by 60 cm, made of PVC polymer is prepared. The weight of the trays is measured before spraying the fluids. The formulated fluid product for the corresponding soil is then agitated well in a mechanical stirrer and sprayed on the desired soil. For better absorption of fluids into the soils, they were maintained static for 24 h and then the formulated trays were transferred outside the laboratory to dry in the open air.

After complete drying, they were subjected to a strong wind tunnel with a length of four metres including a jet engine with a capacity of at least 4000 W and speed of 90-100 km/h for 15-20 min. The trays were weighed after the blowing process and the mass difference of each tray was calculated. All the trays from the beginning to the end of the blowing process were then photographed by a digital camera. One picture is the overall picture of the tray and the other photo is in close-up mode so that the soil structure is well documented and shown. The wind speed was measured at each stage of the tunnel by a digital flow meter. After the end of the blowing process, water was sprayed on all of the trays to simulate the rainy conditions and study its effect on the soil movement and the quality of soil stabilization. Therefore, the surfaces of all trays washed with distilled water and the water remaining on the top was extracted and sent to laboratory and analyzed by GC analysis.

The aim of this idea is to study the rain-washing problem to figure out whether the fluid performance is still maintained after washing out the soil by rainwater. The other reason is to find out if there is still soil stabilization by fluid or the soil is washed with rain and the fluid has become ineffective. This is very important and delicate because many current types of mulch scattered on the soil are washed out completely after the rain and disappear from the surface of the soil.

4. A Complete Description of the Formulated Trays

Working on trays: To formulate the soils and fluids, small or big fibreglass trays were used at first. Subsequently, 40 cm × 60 cm PVC trays shown in Figure 1 were used. The sample soils or the simulated soils with mass of 160 g at first and 600-1000 g afterward were uniformly splashed on surface of trays, followed by spraying the fabricated and diluted green fluid mulch for intended soil. After preparation and initial drying, the trays were transferred to open air of Ahvaz out of laboratory under the sunlight.

Stabilization of soil using wind-blowing test by a digital and strong wind tunnel: For conducting these tests in laboratory scale, two kinds of wind tunnel system were used. The first model observed in Figure 1 contains four main parts as entrance channel, jet fan complex, exit channel and places for putting the trays, with an overall length of 350 cm and speed of 45-48 km/h. In order to increase the tunnel speed, a stronger engine was bought with 3 hp, length of 4 m and speed of 2900 rpm to make huge storms. The dried trays with moderate speed of 75-95 km/h for 15-30 min were subjected to wind blowing and controlled with velocity meter and their stabilization and stability was observed. Next, the trays were weighed by a digital scale and the mass reduction of trays were measured. Finally, some pictures were taken from the formulated trays by a Nikon digital camera with 23-megapixel resolution, before and after blowing process.

Rain-washing test for winded trays: After wind blowing of trays, the soils of trays were wetted completely with abundant water (simulated rain), and the water remaining on top was then extracted and sent to laboratory for GC analysis to ensure that it has no aromatic component or environmentally harmful solvents. At this stage, stability of fluids and soil stabilization were determined and the successful trays with the least mass reduction were selected by using wind-blowing process again.

Conducting the formulated soil stabilization test by planting appropriate plants compatible with soil type and the applied fluid long-term restoration of soil for agricultural purposes and the problem of desertification: In this step of the work, various types of synthesized formulation were selected and applied on ground. After preparing the soil of a categorized ground, the selected fluids were fabricated and mixed with appropriate seeds of season and splashed on actual soil. Some pictures were taken from the planted

and non-planted categorized ground and compared during the growing time. The purpose of farming on domestic agricultural lands was that we could achieve healthy synthesized green biological mulch and produce edible and medical seeds on them. Moreover, it was necessary to build a confidence regarding the formulated mulch fluids in order to suppress the dust of Hamoon Jazmoorian wetland. In addition, the synergistic effect in the development and growth of plants and agriculture in the region was major goals. Figure 1 shows some activities done on soil of engineering college of Tehran university ground. Moreover, during six-month experience in this stage, it was found that the fabricated mulch fluid in this project substantially increased the speed of edible seeds, fodder and medicinal plants. Additionally, the rates of germination and growth of these plants were much faster than usual. Figure 1, shows the two wind tunnels, a digital camera and a view of location where the dust project was carried out in the Environmental Protection Agency in Ahvaz.

It is considerable that, in some areas of swampy Azadegan field in Hour-al-Azim of Hoveyzeh, the old mulching method is still applied using an oil-based formulation prepared from staring materials of the distillation of crude oil in last stages (Petroleum mulch). This method is harmful for both breathing humans and the environment and also causes irreparable damages to all parameters of underground drinking water sources (Vijay K. Bharti et al., 2017). In addition, the aromatic product used is very harmful and unhealthy for the agriculture and local birds and animals. We are hopeful to solve these problems soon using new green synthesized biological mulch fluids and fabricating various water-based formulations (green and natural mulch).

5. Investigation of Performance of Green Fluid in Agriculture and Farming of Organic Vegetable towards Stabilization of the Soil

Figure 2 shows some images related to planting edible, grassy and medicine seeds to fight the dusts of Hamoon Jazmoorian and research and study agriculture problems using optimum amount of sprayed fluids on ground for the survival of soil and agricultural land and stabilization too. The figure shows the Hour-al-Azim of Hoveyzeh soil treated with formulated green fluid and germinated corn seed (without fertilizer). In addition, the categorized ground treated with five various fluids and a part without any fluid as reference, simulated for soils of Jazmoorian wetland including clay, silt + clay, sand + clay, silt + sand and sand are also shown in Figure 2.

Results and Discussion

In this section, the performance of some formulated trays for single soils similar to Ahvaz and new simulated soils of Hamoon Jazmoorian wetland, tested in the

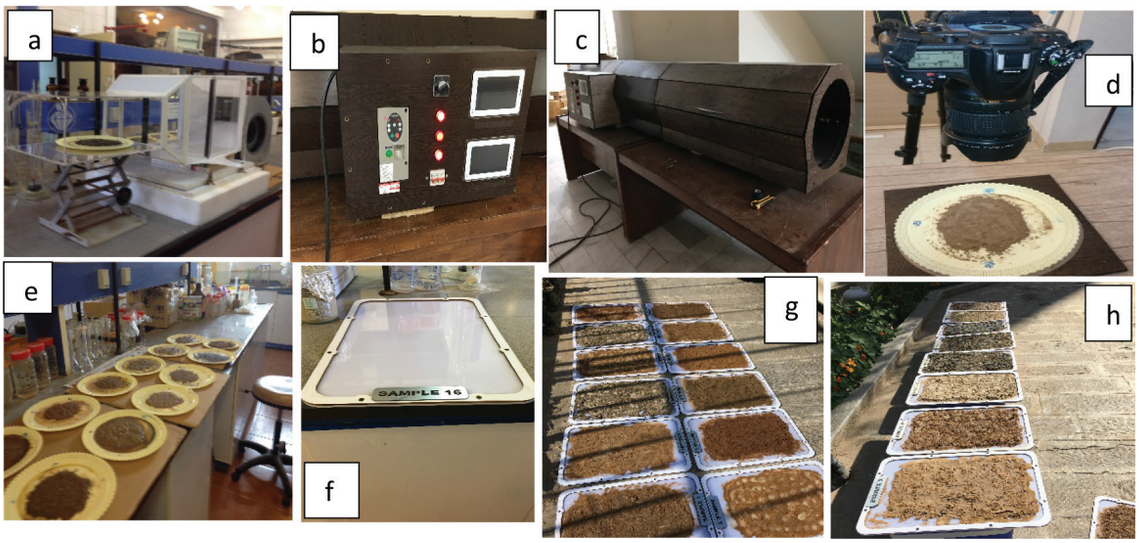

Figure 1: The picture (a) shows image of initial wind tunnel with 45-48 km/h velocity and length of 35 cm. (b) and (c) illustrate images of enhanced wind tunnel with maximum speed of 100 km/h. (d) presents the Nikon camera with high resolution used for taking high quality pictures, (e) shows images of initial circle plates, (f) indicates the picture of PVC tray without formulated soil, and finally (g) and (h) are the formulated soil which had been located in the Environmental Protection Agency in Ahvaz under the direct sunlight, respectively.

Figure 2: Interesting live-images of corn seeds for swampy soils of Hour-al-Azim and other categorized ground for planting edible seeds, green beans, edible organic vegetables and treating them with prepared green synthesized mulch fluids in engineering college of Tehran University garden.

Department of Environmental Protection Agency in Ahvaz, is studied.

A. A formulated mixture of 700 g of three soil types including clays from two areas (Dehno of Hendijan), clay and silt (Gharganeh of Hendijan) is treated with three special fabricated fluids (120 ml) formulated for this simulated soil. Wind blowing tests were successfully performed over the trays. The results of formulated trays are presented in Figure 3, tray No. 18.

B. Fabrication and formulation of 700 g of three soil types (silt and clay) from three individual zones including Gharganeh Hour of Hendijan, Bahregan of Hendijan and Ashareh-ye Omidiyeh were simulated for Hamoon Jazmoorian wetland (Figure 4, tray No. 17). This tray was formulated with three suitable green fluids and wind-blowing tests were carried out successfully over it. Powdered enriched minerals along with green solvents, natural zeolite, wetting agent and dispersant worked very well in these especial fluids so far. The stability of these mixtures of soils was remarkable.

C. Tray No. 13, which includes a kind of single soil (clay and silt) in Gharganeh of Hendijan area, was formulated with 100 ml of diluted fluid for 700 g of soil. Figure 5 shows the appearance and structure of

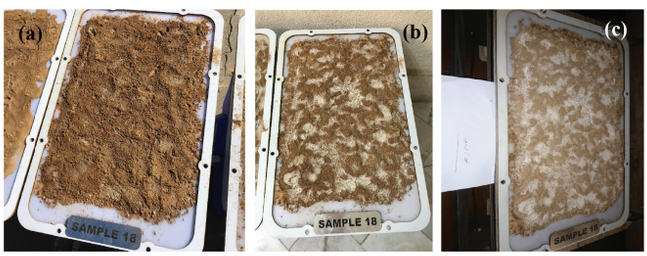

Figure 3: Images of formulated tray No. 18: (a) Initial tray, (b) tray after drying and (c) tray after wind blowing process. The stability and excellent soil stabilization was achieved successfully (the mass reduction was 0.5 g). The formulation contained mineral clays, dispersant, emulsifier, stabilizer, solubilizing, wetting agent, natural anti-oxidant and water solvent. These fluids were able to stabilize clay-silt and special clay soil in Hendijan region.

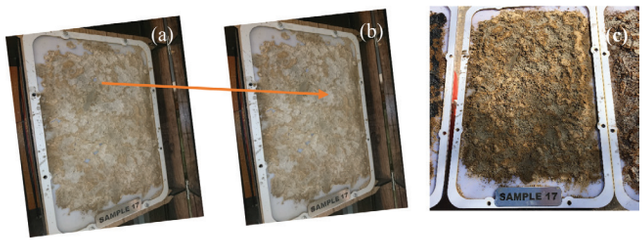

Figure 4: Images of tray No. 17, formulated and simulated for soil (silt and clay) of Jazmoorian wetland: (a) and (b) are trays before and after wind blowing process (speed of 90-95 km/h for 20 min), respectively. The mass reduction was 8.1 g. (c) is tray dried under the sun in Ahvaz according to the regional climate.

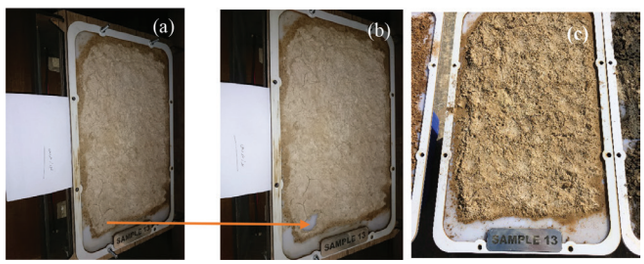

Figure 5: Images of tray No. 13, formulated for single soil (silt and clay) of Jazmoorian wetland: (a) and (b) are trays before and after wind blowing process, respectively. The homogeneity of soil and fluid was amazing. (c) is tray dried under the sun in Ahvaz.

the treated soil. The mass reduction of tray No. 13 was 5.8 g at first and 54 g after 35 days. Generally, it was stable after two years. The ester derivative of coconut oil, which is soluble in liquid formulation and is ecofriendly played an effective role alongside the emulsifier and wetting agents against clay-silt soil in Hendijan area.

D. A very successful formulated tray of simulated soil of Hamoon Jazmoorian wetland includes five types of various soils including silt containing clay from Gharganeh Hour of Hendijan, silt and clay of Bahregan of Hendijan, clay and silt of Gharganeh of Hendijan, silt and clay of Ashareh-ye Omidiyeh and sand of lakehidar in Shoush city. This special formulation was prepared for 500 g of soil and a mixture of three green natural fluids. These fluids were synthesized exclusively for these soils. The fluids were diluted with distilled water, agitated well and then sprayed over the mixture of soils. The formulated tray was subjected to wind tunnel with 90 km/h velocity for 20 min. Figure 6 shows the formulated tray (No. 39). This formulation is one of the best formulations in this research. The applied fluid included hydrating and moisturizing materials, natural mineral composites along with wetting, diluent and solubilizing agent. For this cause, the dried silt-clay soils can remain very fresh and wet for a long time. It is very important that the materials be appropriate and fit special soil type.

E. Fabrication of special formulation (silt and sand) of swampy soils of Hamoon Jazmoorian wetland in tray No. 27. The soil weight is 600 g and the synthesized fluid volume is 100 ml. This soil is simulated exactly from the soil of Azadegan field of Hour-al-Azim of Hoveyzeh region. Figure 7 shows the soil stabilization following wind blowing after 1.5 years. The fluid contains $CaCl_2$ and $MgCl_2$ with the green natural composites, soil moisturizing material, wetting, stabilizing and emulsifier agents in water-based solution.

F. Fabrication of special formulation (silt and clay) of marsh soils of Hamoon Jazmoorian wetland in tray No. 28. For 600 g of the soil, 100 ml of an exclusive fluid was used. This soil is simulated exactly based on the soil of Azadegan field of Hour-al-Azim of Hoveyzeh. Figure 8 shows the appearance of the soil before and after wind blowing. Minerals and zeolites were formulated by emulsifier, anti-oxidant

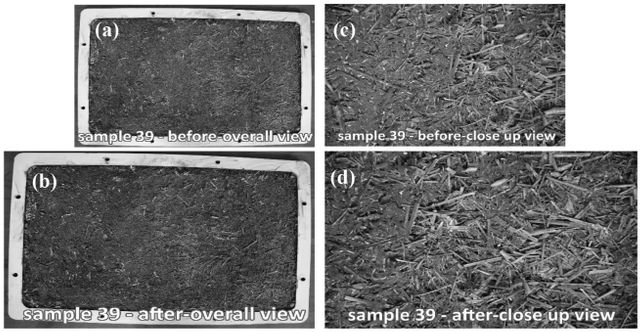

Figure 6: Images of the interesting tray No. 39 formulated for soil of Jazmoorian wetland: (a) and (b) are overall view and (c) and (d) are close-up views of tray before and after severe wind storm process, respectively. The soil was also successfully stabilized. The direct sunrise (the temperature difference varied between 33-51°C during day and night) had no effect on structure of the soil and no crack was observed on it up now (excellent selected formulated tray).

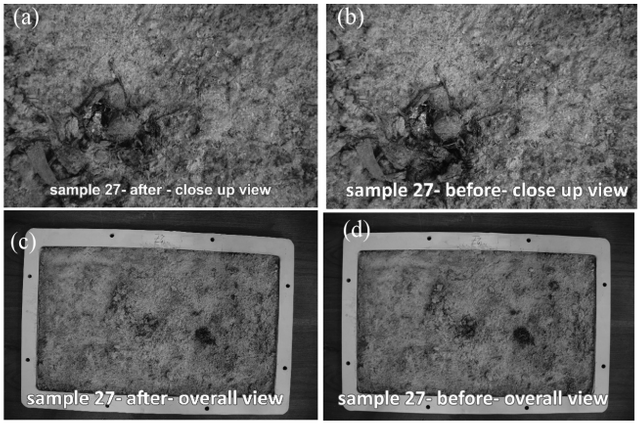

Figure 7: Images of tray No. 27, formulated for soil (silt and sand) of Jazmoorian wetland: (a) and (b) are close-up view and (c) and (d) are overall views of tray before and after wind blowing process, respectively.

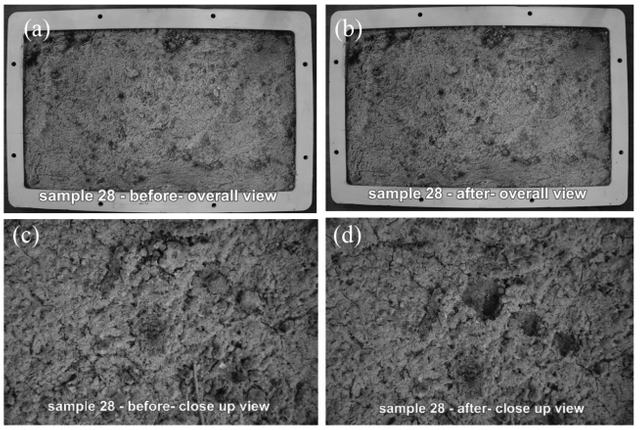

Figure 8: Images of tray No. 28, formulated for soil (silt and sand) of Jazmoorian wetland: (a) and (b) are overall view and (c) and (d) are close-up views of trays before and after wind blowing process, respectively, after 1.5 years.

and green fatty acids in a polar, benign solvent in this special fluid for tray No. 27.

G. Fabrication of special formulation (silt and sand) of marsh soils of Hamoon Jazmoorian wetland in tray No. 41. The formulation fabricated for silt and sand was successful in the stabilization of light and fine swampy soils, tolerated the variations of local temperature well and the wind speed of 90-95 km/h. Figure 9 shows the results for formulated tray No. 41 (Check unparalleled durability, biological fluid into the soil after 1.5 years). Natural materials mines, MgO nanoparticles, adhesives material, softening agents, solubilizes and dispersants in water solution produced this mulch fluid for silt and sand.

In addition, the rain washed tray No. 41 after water spray in and drying outside the room is shown in Figure 10. Soil stabilization after eight months of rain washing process for formulated No. 41 tray has been shown.

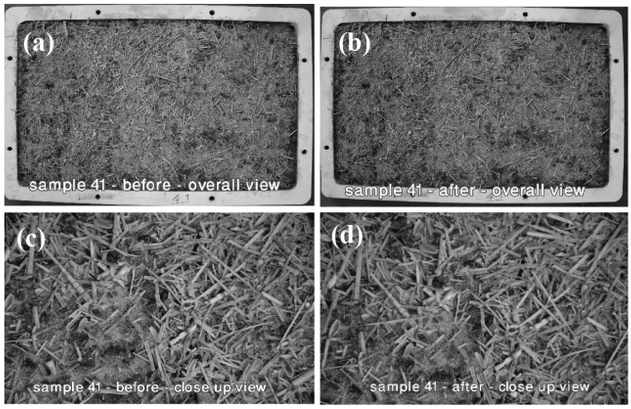

Figure 9: Images of tray No. 41, formulated for soil (silt and sand) of Jazmoorian wetland: (a) and (b) are overall view and (c) and (d) are close-up views of tray before and after wind blowing process after 1.5 years of making, respectively. The weight of the soil was 600 g and it contained 100 ml of newly synthesized mulch fluid. It was found that the soil became very stable by using this fluid product so far.

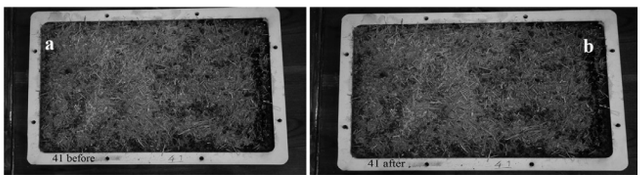

Figure 10: Images of tray No. 41 after eight months of rain washing process: (a) before wind blowing and (b) after wind with speed of 95 km/h for 25 min. The trays are very stable and soil has been established completely without any weight loss.

H. Two different formulations for silt and clay in small circular plates with suitable fluids were fabricated and subjected to wind tunnel (80 cm in length, having a centrifugal fan engine structure with 0.5 hp) and a speed of 48 km/h for 17 min (the mass reduction was quasi null or about 0.8 g). The soil stabilization was considered next, about one year after spraying fluids. The heating test of formulated trays was carried out in 60-75 °C range in order to apply the intensive heat of summer in wetland area and study the soil stabilization under these conditions. Two fluid samples including silt and clay soil with different formulations in plates No. 18 and 25 are shown in Figure 11. A month after drying and the first wind blowing, plate No. 18 was washed with 42 ml of water, fully saturated, dried in the laboratory and an oven at 70-75 °C and again subjected to wind tunnel with speed of 48 km/h for 25 min. The results were amazing and wonderful. The objective of this test was to study the effect of rain-washing of the formulated plate to simulate the rainy days in order to prevent washing the content of fluids on the plate because the soil can move and lift into the air again after drying. This is one of our greatest concerns in splashing the fluids on soils for the soil stabilization. Therefore, this issue has been studied for all of the formulated trays.

Conclusion

In this study, eight different green fluids suitable for silt + clay soils, swampy, silt + sand and clays for Hamoon Jazmoorian wetland were synthesized and formulated for the first time. In this regard, some of these soils were adapted directly from Khuzestan province soils and the others were simulated based on the soil of Hamoon Jazmoorian wetland. Accordingly, various new green water-based fluids including natural materials of domestic mines and active additives, as each of them was needed for a special role in the fluids, were fabricated. None of the main components used in the formulation of the new mulch fluids are aromatic or dangerous paraffinic compounds and harmful for human and environment. In addition to the stabilization of soil, most of the main components and herbal solvents are useful for strengthening, nourishing and maintaining soil moisture.

In this current research, the soils were weighed in big PVC trays and fluids were sprayed on them. Having been dried under the sun, the soils were subjected to

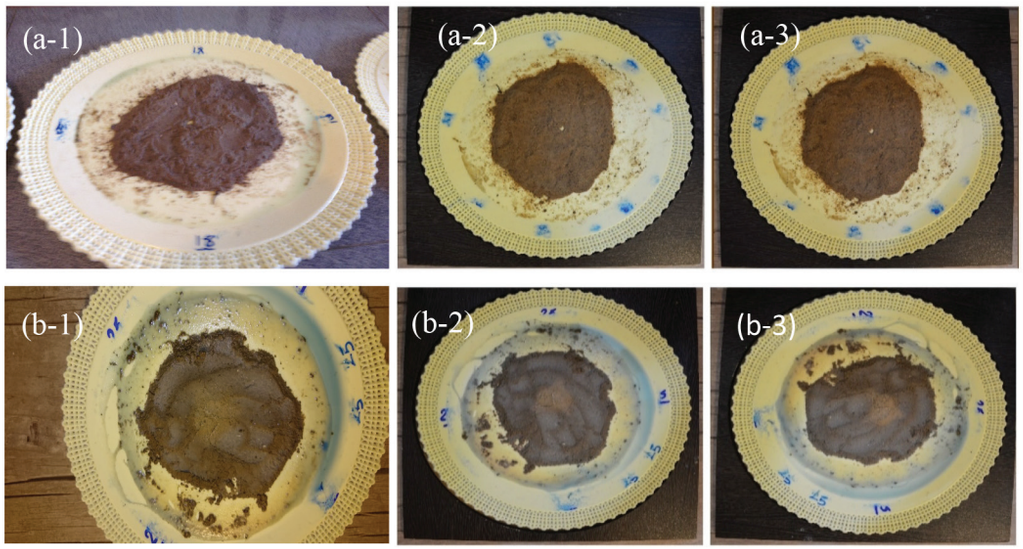

Figure 11: Images of plates No. 18 and 25, formulated for soil (silt and clay) of Jazmoorian wetland: (a-1) overall view of tray No. 18 after the first wind blowing process. (a-2) and (a-3) are plate No. 18 before and after second wind blowing process. (b-1) is overall view of plate No. 25 after the first wind blowing process. (b-2) and (b-3) are plate No. 25 before and after second wind blowing process. The first and second wind blowing processes took 25 and 17 min, respectively. No changes were observed in stabilization of soil after rain washing and blowing processes after more than two years.

intensive wind blowing in a high speed wind tunnel for 15-20 min. Despite the good performance of the synthesized green mulch fluids in soil stabilization, they are not expensive since all the fluid components are commercially available. Moreover, attempts have recently been made to produce 10 tons of original green biological mulch product in industrial scale for spraying in sand hills of Susangerd also known as Dasht-e Azadegan located 55 km north of Ahvaz. It is important to study the mechanism of performance of every single material in the mulch fluid based on the kind of soil in operation area. However, since most of the fine dust constantly moves from one place to another, the actual structure of the soil changes and become very complex. Therefore, the best research approach is to carry out actual tests. However, environmentally friendly compounds, which are capable of penetrating into the soil to a certain depth, generation of strong adhesion strength, absorbing water from the environment and rain and finally maintain soil moisture are required for this purpose.

In this case, this restored soil can be stabilized for a long time. In addition, the planting of seed or trees on them can make them more stable and give them a life again. However, the main texture of the basic soil remains unchanged since the surface layer of the soil is involved rather than its depth. Another important point in fluid formulation is that, no poisonous and hazardous aromatic solvents or substances for humans and the environment or toxic petrochemical polymers are used. Due to the large variety of soil types, it is necessary to deal with each soil individually and produce special formulations for it, since one general formula certainly cannot fulfill all our demands and becomes unstable and loses its quality in the long run. According to the statistics, the amount of existing or high potential deserts for making dust in Iran is 32 million hectares, of which 70-80 thousand hectares are mulched or planted yearly in order to combat desertification. Therefore, the importance of performing projects carried out in polluted areas to fight fine dust is obvious; especially when dealing with the health and wellness of human and cleanness of air dust contaminated areas. It is worth noting that the results of this work can be applied for other lands and dust focal and deserts of Iran and neighbouring cities and other countries, like Hamoon Jazmoorian wetland in the industrial scale. The knowledge of cognition of soil types and application of innovative technologies for water-based green biological mulch fluid for environmental technology, and also clean or common green technology and considering the health of people and environment cleanup is a

series of requirements in this project. Drying process of Jazmoorian wetland caused the fine dust and sand storms which become the guest of cities and villages around the wetland. In addition, the western winds from early spring to late summer pour dust upon the people of Delgan and Iranshahr in southwest of Sistan-Baluchistan and make life hard for them.

Declaration of Interest

The author(s) declared no potential conflicts of interest with respect to this new research, authorship, and publication of this paper.

Acknowledgements

The authors would like to thank the honourable supporters of this project; especially Dr. Lahijanzadeh, the head of the Environmental Protection Agency of Khuzestan province, Dr. Moghtadaei, Dr. Shariati, the former governor of the Khuzestan province, members of the general administration of Khuzestan provincial disaster management, Professor Dr. Mousavian, the head of Department of Chemical Engineering, University of Tehran and all our colleagues in agriculture section of the Technical College of University of Tehran in north Amir Abad. The support and frequent encouragement of the respected authorities for the progress of this work are gratefully acknowledged.

References

Bahari, A., Ashrafi, F., Babenejad, A., Barimani, F., Sedghi, K. and N. Habibzadeh (2011). Investigation and characterization of Nano clay structures. *Arch. Appl. Sci. Res*., **3:** 462-469.

Fakhroueian, Z., Attarnejad, M.A., Esmaeilzadeh, P., Forouzafard, F., Khaksar, E., Lahijanzadeh, A.R., Karampour, A. and A. A. Mousavi (2016). Successful stabilization of eight focal points of the desert field soils in Khuzestan province using the new sustainable water-based nano and micro-fluids (green Mlach) presented in the first international conference on dust, Ahvaz, March.

Giri, A., Bharti, V.K., Kalia, S., Kumar, K., Raj, T. and B. Kumar (2017). Utility of Multivariate Statistical Analysis to Identify Factors Contributing Groundwater Quality in High Altitude Region of Leh-Ladakh, India. *Asian J. Water, Environ. Pollution*, **14:** 61-75.

Guidance for Temporary Soil Stabilization (2003). State of California Department of Transportation.

Hamoun Wetlands Current Situation and the Way Forward, Link: www.ir.undp.org.

Panahi, M., Khosravi, M.R., Blake, J., Derakhshi, F. and S. Ferdowsi (2005). United Nations Development Programme, I.R. Iran, Restoration and Sustainable Use of the Shared Sistan Basin. A Baseline Situation Analysis.

Rafia, A., Nasir, H.M., Muhamad, A. and Ibrahim Akma (2006). Impact of Air Pollution on Health in Klang Valley, Malaysia. *Asian J. Water Environ. Pollution*, **3:** 27-38.

Rusul Khaleel, I., Maan, H., Mohammed Abdulhakim, A., Adeeb, H. and I. Shaliza (2016). Environmental application of nanotechnology: Air, soil and water. *Environ Sci Pollut Res*., 1-35. DOI 10.1007/s11356-016-6457-z

Section IV: Dust Control and Stabilization / Types of Stabilizers (2003). pp. 51-56. https://www.epa.gov/sites/production

Sharma, B., Sharma, S. and S.K. Bhardwaj (2017). Plant-Pollutant Interactions with a Special Mention of Dust Accumulation by Plants – A Review. *Nature Environ. Pollut. Tech.*, **16:** 375-384.

Spraying Systems Co (2008). Experts in Spray Technology, Efficient, Effective Solutions for Dust Prevention and Suppression. Bulletin No. 652. Printed in the U.S.A. http://www.spray.com

Tripathi, S. and D.K. Mishra (2007). Importance of surfactant adsorption in soil and ground water remediation. A thesis for the degree of Bachelor of Technology in Chemical Engineering.

Yana, S., Yongzhong, S., Guangyu, Z., Shengliang, Z. and J. Jiehua (2017). Comparison of air pollution in Shanghai and Lanzhou based on wavelet transform. *Environ. Sci. Pollut. Res.*, open access: 1-10. DOI 10.1007/s11356-017-8959-8