Innovative Method of Treating soil with Waste Water for Control of Dust and Establishing Soil Stabilization

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ABSTRACT

Wind erosion of soil is a significant problem throughout the World. In India many parts of Rajasthan, Gujarat & coastal areas are highly prone to dust formation. Due to small particle size and poor cohesion, finely divided soil is sensitive to the influence of Wind. Such finely divided soil is found in agricultural lands, dunes, lake beds, construction sites and roads under construction. Moreover, the effects of Wind erosion on soil can be enhanced by the influence of the sun and rain. This is a particular problem when agricultural soil is washed away, damaging plant life and making the soil unusable for agricultural purposes. The method which we used is to cater soil stabilization and to control dust from soil. Soil stabilization refers to the treatment of soils with chemicals to offset the tendencies of soils to be sensitive to small changes in the types of ions in the soil moisture as they affect the plasticity of the soil. The added advantage of this method is the application of unwanted waste water produced in purifying Water. The method includes applying waste water containing 0.15% by weight of the salts of NaCl, $CaCl_2$, $MgCl_2$ and mixtures thereof to soil to control dust and effect soil stabilization. Thus, by the application of salty water we have found a method to eradicate three problems i.e. disposal of waste water by the application of it, devastating effects caused by dust, and loss of soil plasticity due to destabilization of soil.

Keywords: erosion; soil stabilization; waste water; soil plasticity

1. INTRODUCTION

In a first respect, the invention relates to methods for controlling dust and effecting soil stabilization. In a second respect, the present invention relates to the disposal of waste water. Wind erosion of soil is a significant problem throughout the world. Due to small particle size and poor cohesion, finely divided soil is sensitive to the influence of Wind. Such finely divided soil is found in agricultural lands, dunes, lake beds, construction sites and roads under construction. Erosion by Wind causes the drifting of masses of soil in the form of dust. The erosion by Wind causes the inconvenience of dust formation and the loss of valuable matter such as seed, fertilizer and plantlets. Dust storms are a danger to traffic and a health risk to persons residing in the vicinity. Moreover, the effects of Wind erosion on soil can be enhanced by the influence of the sun and rain.

The sun causes the evaporation of moisture from soil thereby reducing the cohesion of finely divided soil. Erosion of the soil by rain is caused by rain washing away soil. This is a particular problem when agricultural soil is washed away, damaging plant life and making the soil unusable for agricultural purposes. Further, due to the influence of erosion by rain, the unprotected slopes of ditches, channels, dunes and roads may collapse or be washed away. Therefore, it is extremely important to prevent the effects of the sun, wind and water in eroding soil. It has been proposed to prevent the shift, drift and erosion of soil by treating the surface layers of the soil with water dispersible high polymeric substances of a natural or synthetic nature. Examples of these high polymeric substances include starch, ethers, hydrolyze polyacrylonitril, polyvinyl alcohol and carboxymethyl cellulose. From earlier knowledge, we are aware of the use of polyvinyl acetate as an anti-erosion agent, conditioning of soil with mono starch phosphate, treating the soil with a pre-gelatinized starch and a surfactant compound. Furthermore, it has been known to treat dirt roads with relatively pure solid sodium chloride (NaCl), calcium chloride ($CaCl_2$), and mixtures of the two. There are several drawbacks with the aforementioned soil treating compounds. The polymers mentioned have a relatively high price and have potentially harmful environmental properties. In addition, the starch ethers have proved sensitive to washing out by rain water. As a result, their effectiveness as an anti-erosion agent is severely limited. Furthermore, it would be highly desirable to provide a method for treating soil that is of low cost and utilizes a material or compound which is readily available. Accordingly, it would be highly desirable to provide a method for treating soil to control dust and effect soil stabilization. As used herein, soil stabilization refers to the treatment of soils with chemicals to offset the tendencies of soils to be sensitive to small changes in the types of ions in the soil moisture as they affect the plasticity of the soil. For example, swelled clays, those with layers of “bound” Water molecules, are more susceptible to movement under load. Soil stabilization of swelled clays can be effected by altering the types and/or amounts of ions in the soil mixture. An additional problem encountered throughout the World involves the disposal of Waste Water. The softening of hard Water by the removal of calcium and magnesium is required for both industrial and household use.

Water softening processes proceed either by way of ion-exchange, membrane softening or precipitation. In the ion-exchange processes, the calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions are exchanged for sodium (Na^{+}) and regeneration of the ion-exchange resin is achieved with a large excess of NaCl. This process creates a regeneration effluent being a relatively concentrated aqueous solution of sodium, calcium and magnesium chlorides which has to be discarded. Consequently, by this method, considerable amounts of sodium, calcium and magnesium salts in solution must be disposed of. Alternatively, it is possible to use weak acid resins which exchange hydrogen (H") for calcium (Ca2+,) and magnesium (Mg_2), and to regenerate the spent resins with a mineral acid. While this method creates less waste water, it is more expensive and yields relatively acidic soft water which is corrosive. Meanwhile, membrane softening concentrates the calcium, magnesium salts and salts of other divalent ions to produce waste waters which require costly disposal.

The precipitation process has traditionally been carried out by the “lime soda” process in which lime is added to hard water to convert water soluble calcium bicarbonate into water insoluble calcium carbonate. This process also results in waste water which is difficult to filter and requires cumbersome treatment. The disposal of waste water has become an expensive problem for society. For example, approximately 1.61 billion gallons of waste water containing approximately 800, 000 tons of mixed sodium, calcium and magnesium chlorides and sulfates is produced from water treatment operations and oil fields in the State of California alone. This waste water must be disposed of, costing millions of dollars. Accordingly, it would be highly advantageous to provide an improved method of disposing of salty waste waters. It would even be more advantageous to provide a method of disposing of salty waste waters which provides a benefit to society. It would be even more advantageous if salty waste waters could be used to treat soil to control dust and effect soil stabilization.

2. METHOD USED

2.1 Description of Method Used

Water softening is the removal of the “hardness” from the water which means predominantly removing or altering the calcium and magnesium ions from the water. These calcium and magnesium ions combined with carbonates, sulfates, oils and fat to create bathtub scum, spotted dishes, gray sheets, etc. In addition, unsoftened water has been found to cause scaling of industrial water heaters and commercial boilers causing early substantial energy losses through impaired heat transfer and early shutdown for the removal of scale. Several methods for effecting water softening are known. The best known process for softening water is “ion-exchange”. Ion-exchange entails the exchange of sodium, which is introduced into water, for calcium, magnesium, iron and other divalent mineral ions which are transferred out of the water and into a resin. When the resin approaches saturation with these hard ions, the resin is regenerated most often with solutions of sodium chloride leaving an effluent containing 3 to 25% sodium, calcium and magnesium salts which must be disposed of. The exact concentration of the effluent depends on the shop practice and, in particular, on the amount of rinse water included in the effluent, if any. Less often mineral acids like sulfuric or hydrochloric acid is used for water softening and these also produce effluents. Membrane systems have recently become economically feasible. These systems, such as electro dialysis and reverse osmosis, include the use of a membrane which also produces a salty effluent. For critical uses such as electronics, and particularly for use in the manufacture of computer chips, the first product of clean water may be further purified by dual bed or mixed bed ion-exchange treatment. This "polishing treatment" also produces an effluent containing the removed salts. Each of these water purifying processes produce a clean water effluent and a waste water effluent which is expensive and difficult to dispose of. The chemical and physical properties of clays and soils have ion-exchange properties which are determined in great part by their contact with water soluble chemicals. Chemicals having particular influence on the physical properties of soil are sodium, potassium, calcium and magnesium because these are common cations. The most common anions found in soils are chloride, sulfate, carbonate and bicarbonate. The concentration, and relative concentration, of the various dissolved ions determine the activity of the exchangeable ions attached to soil particles. Thus, it is possible to alter and regulate the behavior of soils by controlling the ratio and amount of the various ions applied to the soils. More particularly, I have found that sodium chlorides have much greater effectiveness in stabilizing soils than the calcium and magnesium salts. Conversely, I have found that the calcium and magnesium chlorides have much greater effectiveness in controlling dust from windblown soil than sodium salts. I have also found that, in general, the calcium and magnesium salts do not noticeably interfere with the sodium chloride's ability to stabilize soils, while the sodium salts do not reduce the effectiveness of calcium and magnesium chlorides for dust control. For the purposes of this invention, "waste water" is defined as any water containing sufficient salts as to have no acceptable use due to costs or contamination levels. In general, waste water containing about 0.15% or more by weight of the salts of $NaCl$, $CaCl_2$, $MgCl_2$, or combinations thereof are considered as having no acceptable use and must be disposed of. With reference to FIG. 1, in a preferred embodiment, water is collected which is contaminated with salts including $NaCl$, $CaCl_2$ and $MgCl_2$. The contaminated water is purified by any means known to those skilled in the art, including distillation, reverse osmosis, electrolysis, evaporation, ion exchange, etc. The contaminated water is processed to produce a first effluent of relatively clean water which is useful for agricultural purposes, drinking Water, industrial purposes, etc. The processing also produces a second effluent of waste water. The waste water is analyzed for hazardous materials to confirm that the waste water is safe to use. Thereafter, the waste water, comprising a solution of salts, is analyzed for individual amounts of sodium, calcium, and magnesium and total dissolved solids to determine the best application and the amount of solution to be applied to a particular soil. The waste water is then applied to soil by spraying from a truck, aircraft or the like to effectively control dust and stabilize the soil. Where the concentration of salts is not enough to meet the required needs in a single application, several applications of the waste water may be employed. With reference to FIG. 2, in a second preferred embodiment, water is collected which is contaminated with the salts of Na, Ca, Mg, Fe, Cl, $S0_4$, CO_2, etc. The water is then tested to confirm that it is free of hazardous materials. The contaminated water is then purified by ion exchange. As the name implies, the amount of salts in the effluents does not change. However, the cations exchange for anions. By this process, a first effluent of clean water is produced having an increase in sodium or potassium. Where the contaminated water originally contained a low amount of sodium, it is preferred that this water be used for potable water. Meanwhile, where the contaminated water originally contained high sodium amounts, it is preferred that the clean water effluent be used for laundries, boilers, cooling, towers, pond sealing and soil stabilization. These uses are listed in order of suitability as the sodium increases. As shown in FIG. 2, the water softening process by ion exchange also produces a waste water having decreased NaCl, KCl, $Na(OH)_2$ or acid, but having an increase in calcium and magnesium. This waste water is then applied to soil by spraying from a truck, aircraft or the like to control dust. With reference to FIG. 3, in a fourth preferred embodiment, water is collected which is contaminated with the salts of Na, K, Ca, Mg, Fe, Cl, $S0_4$, and CO_3. The water is then tested to confirm that it is free of hazardous materials. This contaminated water is then purified by a membrane system to remove large molecules. A first effluent of clean water having decreased divalent ions is produced from the membrane softening process. Where the original sodium content of the contaminated water is relatively low, it is preferred that the clean water be used for potable water. Where the original sodium content of the contaminated water is relatively high, it is preferred that the clean water effluent be used for laundries, low pressure boilers, cooling towers, pond sealing and soil stabilization. The membrane system also creates waste water having increased calcium, magnesium, iron, sulfates, etc. It is preferred that this waste water be applied to soil by spraying from a truck, aircraft, or the like to effectively control dust. As shown in FIG. 4, in a fourth embodiment of my invention, water contaminated with the salts of NaCl, $CaCl_2$ and/or $MgCl_2$ is collected. The contaminated water is desalted to produce a first effluent of relatively clean Water, and a second effluent of waste water. The second effluent undergoes further evaporization processing to produce a first product of 90% or more NaCl, and a third effluent solution of substantially saturated $CaCl_2$, and $MgCl_2$. The NaCl is then applied to soil to effect soil stabilization. Meanwhile the third effluent solution of mixed $CaCl_2$ and $MgCl_2$ is applied to soil to effect dust control. As would be understood by those skilled in the art, the preferred amount of water and the percentage of salts contained therein to control dust and effect soil stabilization will vary greatly. Factors which will effect waste water applications include the chemical composition of the soil, the moisture in the soil, humidity, local rainfall, traffic conditions, etc. Since the testing of soil is expensive, it is preferred that the waste water be applied in several applications. Waste water is applied and allowed to evaporate. The soil is examined to determine if sufficient waste water has been applied to control dust or stabilize the soil. These steps are repeated until sufficient salts have been applied to control dust or to stabilize the soil.

2.2 Brief Description of the Drawing:

FIG. 1 is a flow chart of the preferred method of the invention;

FIG. 2 is a flow chart of another preferred method of the invention;

FIG. 3 is a flow chart of still another preferred method of the invention; and

FIG. 4 is a flow chart of a preferred method of the present invention including evaporation to produce substantially solid sodium chloride.

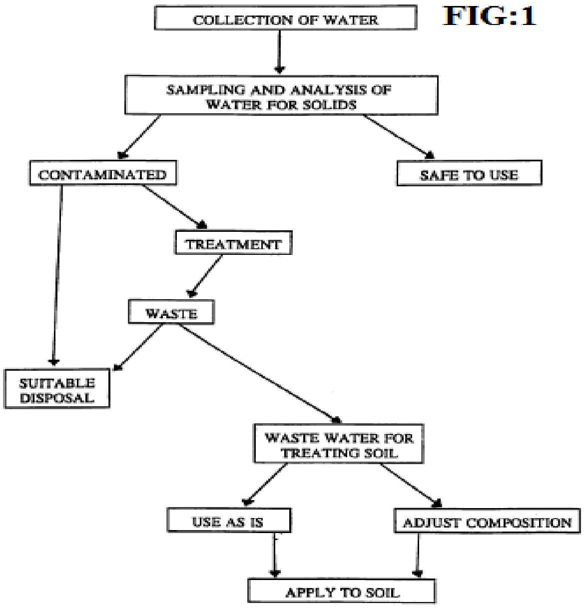

FIG:1

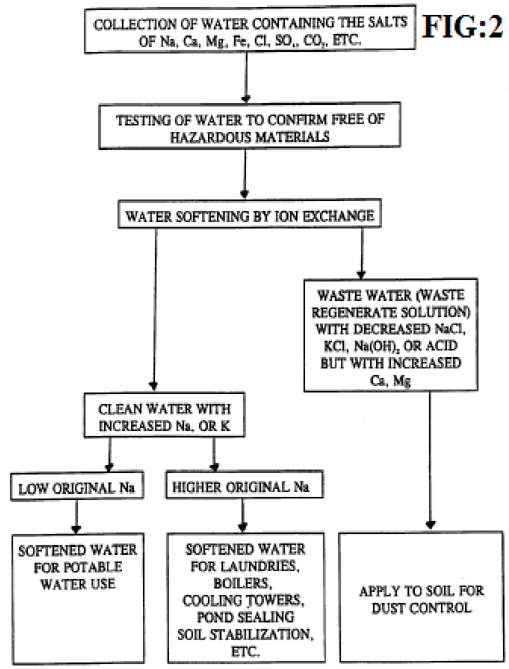

FIG:2

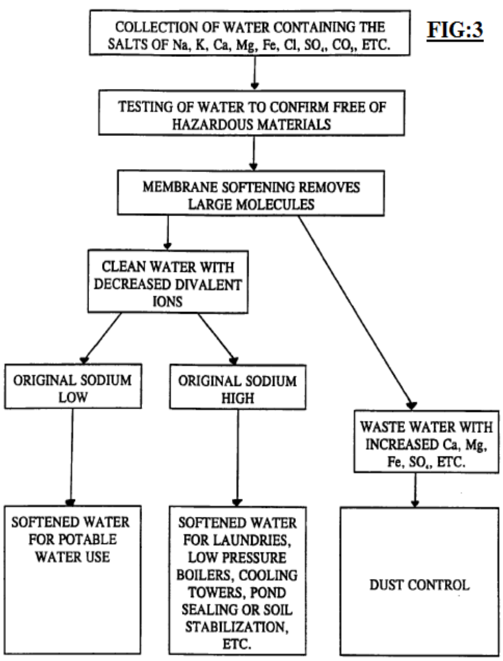

FIG:3

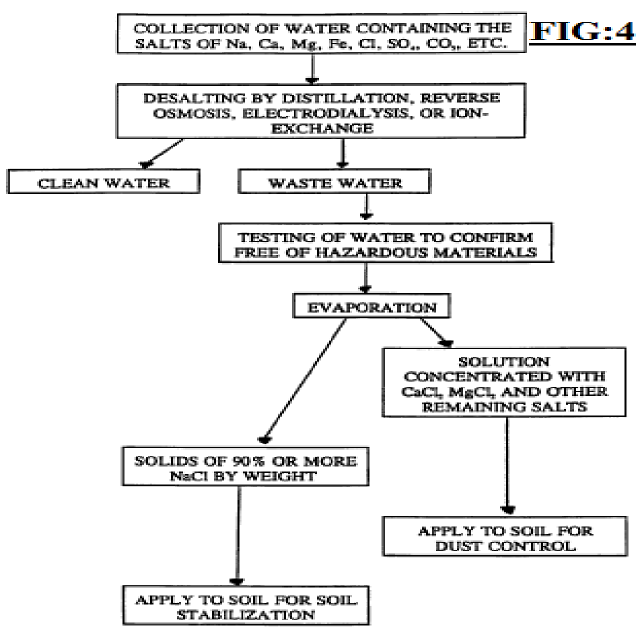

FIG:4

3. RESULTS

On applying the method to various plots of land and then comparing the dust formation and stabilization, firstly when there is no application of waste water and secondly when we treat the soil with the waste water.

It shows that the dust formation is greatly reduced when we apply the waste water till the maximum absorption of soil. It also proves effective for soil stabilization. Compared to untreated sections, the soil is found to be more stable and less prone to being spread by rainfall, and is found to be much less prone to wash boarding and potholing.

4. CONCLUSIONS

This method proved to be very effective than any other methods available for erosion control or for treatment of waste water, firstly this method is very efficient and cost effective, so keeping in view the Indian conditions, we can easily include this method to eradicate the problem of wind erosion and disposal of waste water simultaneously. Thus the Government and all the concerned authorities should aware people and farmers of the benefits of this method and its advantages over other methods. If all farmers, industries start following this method then we can be saved by the ill effects of erosion and waste water containing harmful chemicals, leading us to sustainability and conservation of soil.

REFERENCES

[1] Azizov A. 1977. Influence of soil moisture on the resistance of soil to wind erosion. *Soviet Soil Science* **9**(1): 105–108.

[2] Bagnold RA. 1941. *The Physics of Blown Sand and Desert Dunes*. Chapman and Hall: New York.

[3] Bauer BO, Namikas SL. 1998. Design and field test of a continuously weighing, tipping-bucket assembly for aeolian sand traps. *Earth Surface Processes and Landforms* **23**: 1171–1183.

[4] Bielders CL, Michels K, Rajot JL. 2000. On-farm evaluation of ridging and residue management practices to reduce wind erosion in Niger. *Science Society of America Journal* **64**: 1776–1785.

[5] Bilbro JD, Fryrear DW. 1995. Wind erosion losses as related to plant silhouette and soil cover. *Agronomy Journal* **86**(3): 550–553.

[6] Bisal F, Hsieh J. 1966. Influence of moisture on erodibility of soil by wind. *Soil Science* **102**(3): 143–146.

[7] Boyd DW, Skidmore EL, Thompson JG. 1983. A soil-aggregate crushing-energy meter. *Science Society of America Journal* **47**: 313–316.