RETRACTED ARTICLE: Research on desert water management and desert control

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ABSTRACT
Ecological restoration in desertified areas is a worldwide problem. Vegetation restoration is the most sustainable method. But vegetation restoration is facing the challenge of scientific water use. The most effective method of scientific water use is to introduce new material technologies and scientific water management. In this paper, the principles and characteristics of water science materials in recent years are comprehensively analyzed, which includes the interfacial structure and water transport mechanism principle of structural micro-water irrigation technology, the structure self-differential dynamic principle and water transfer dynamics of water molecule infiltrated irrigation Materials for Self-regulating soil moisture, preliminary scientific analysis and biomimetic structure test of biomimetic gel, water storage principle and characteristics of sand surface crust biomaterials. In addition, according to the characteristics of desert water resources, future research fields and characteristics of desert water science materials are inferred, and the new material technology of “smart irrigation” and “waterless irrigation” will be the leading direction for future development. However, sand control is the most fundamental solution. Combined with the experience of sand control in the non-Kubuqi desert in China, specific sand prevention plan is put forward.

Introduction
Desertification is the focus of environmental issues of concern to the world today, and its hazard ranks first among the top ten disasters in the world (Vorovencii, 2017). The expansion of deserts engulfs productive arable land, resulting in harsh sand and dust climates, leading to poverty and ecological migration (Xue et al., 2017). The harsh desert environment has led to frequent wars in history (Sterk et al., 2016). The ecological, economic and social problems of desertification resulted in the extinction of ancient Egyptian civilization and ancient Babylonian civilization (Cui et al., 2017). China is one of the countries most seriously affected by desertification in the world. As of 2014, the desertification area of China was 2.66 × 106 km2, accounting for 34 times of the total land area (Hairong, 2008). It continues to expand at the rate of 2460 km2/a (Du Hongmei & Zengzhi, 2017).

The essence of desertification is that some living organisms which are suitable for growth on the original land can not be restored, the soil productivity is obviously degraded, and the means of production on which human beings depend for survival and development cannot be implemented and regenerated (Xu et al., 2017).

In 1997, the United Nations Conference on Desertification made a comprehensive statement on desertification: Desertification is the degradation and destruction of the biological resources of the land, which ultimately leads to scenarios similar to the desert. It aggravates, weakens or destroys the biological potential of the ecosystem, which destroys the multipurpose plant and plant production capacity that supports human development and meets the growing needs of the population (Secretariat of the United Nations Conference on Desertification, 1977).

The most sustainable way to carry out ecological restoration on desertified land is vegetation restoration. The fundamental problem of vegetation restoration is water.

If the groundwater is upgraded to the surface for ecological restoration, the water demand is large because the surface water can not be stored, cultivated, conserved and circulated, not only because the soil structure can not guarantee the survival of the plants, but also leads to the evaporation and infiltration of a large amount of water resources, and resulting in the decline of the groundwater level. Strong surface evaporation and groundwater levels above critical depth are the most direct causes of soil degradation (Jingsong, 1995; Junhou & Shouxia, 1998). Therefore, extensive on-site water abstraction for large-scale ecological restoration is an unsustainable measure and method.

Water is the most essential material indispensable to all living things. Without water, there is no life, and the solution to the problem of desertified water has become a worldwide problem (Croke et al., 2000; Wan...
et al., 2016). The source of water in the desert consists of artificial external water, groundwater, sand adsorbed water, precipitation and air water. Artificial foreign water and groundwater must be limited to the most limited amount, the purpose is to ensure the benign cycle of ecological restoration and the economic problems of water application. So far, the research in this field is limited and mainly focused on mechanical micro-irrigation. However, there is still a wide range of research space in this field, especially the introduction of new material technology is a worthy of attention.

In recent years, people have tried to restore desert ecology without watering. As a result, bionic condensation materials, sand surface biological crust materials, water absorbent resin materials have emerged (Xinru et al., 2006a; Fan et al., 2017; Mogul et al., 2017; Liao et al., 2017; Wei et al., 2017; Zheng et al., 2010). The appearance of these materials provides a new direction for ecological restoration in desertification areas.

On 2 June 2009, the Institute of Interface Engineering and Biotechnology of the Fraunhofer Institute of Germany announced that the Institute and a German company have collaborated to develop a equipment that could automatically convert moisture into drinking water in the air. It can help residents in the desert to solve some of the water shortage problems. Because even in the desert, the air still contains available moisture. In Israel’s Negev desert, the annual average relative humidity of the air is 64%, which is equivalent to 11.5 ml of water per cubic meter of air. Principle of and usage method of water intake in air are shown in Figures 1 and 2 respectively.

This device relies entirely on solar-powered heating and can be used in areas where there is no electricity grid. Its core technology is to absorb the moisture in the air by the moisture absorption of salt water. The first step is to let the brine flow down the top of a tower and absorb moisture from the air during this process. The brine is then pumped into a vacuum vessel several meters high, and the water is distilled from salt free water by heating the diluted salt water with solar energy. The vacuum vessel is used to boil the salt water at a temperature below 100 degrees Celsius, thereby reducing the energy consumption during distillation. The flow of distilled water in a special filling pipe is a continuous vacuuming process, so as to avoid the use of a vacuum pump. The distilled water will be reintroduced into the top of the tower to absorb the moisture in the air.

In this paper, the principles and characteristics of water science materials in recent years are comprehensively analyzed, which includes the interfacial structure water transport mechanism and water droplet formation principle of structural micro-water irrigation technology, the structure self-differential dynamic principle and water transfer dynamics of water molecule infiltrated Irrigation Materials for Self-regulating soil moisture, preliminary scientific analysis and biomimetic structure test of biomimetic gel, water storage principle and characteristics of sand surface crust biomaterials. In addition, according to the characteristics of desert water resources, the future research fields and characteristics of desert water science materials are inferred, and the new material technology of “smart irrigation” and “waterless irrigation” will be the leading direction for future development is put forward.

**Review on the development of materials in desert water science**

**Structure effect of micro water irrigation under external pressure**

Drip irrigation technology is the process of transforming continuous medium water fluid into regular intermittent drip irrigation under external pressure. Although this process can not self regulate soil moisture, it has achieved effective water saving. The use of this technology has made Israel’s per capita agricultural output rank second in the world (Mali et al., 2017; Pavel et al., 2017). The essence of drip irrigation is the flow of water in the microscale space.
Eringen (1964) first proposed that fluid flow at microscales has deviated from the classical fluid theory. When the flow channel size is small to a certain extent, the microscopic motion of the fluid molecules must be considered. At this time, the flow should be characterized by particles. Especially when the flow channel size is close to the fluid particles, the fluid microcluster density continuity assumption is no longer valid (Ariman et al., 1973). The micro water is turbulent in the emitter and interpenetrates between the layers of the fluid. In addition to the longitudinal velocity, there is also a pulsating velocity along the vertical direction of flow. This pulsation phenomenon consumes a large amount of energy, which makes the flow resistance increase significantly. Finally, the energy dissipation effect of the turbulent flow irrigator is stronger and the uniformity of the effluent is higher. As the critical Reynolds number of the small flow channel is smaller than that of the conventional channel, the flow channel structure of the irrigation channel is changeable, which will help the flow of water flow from the layer to turbulence. Xiaoning (1996), Buxuan & Xiaofeng (1998), Zhanhua & Xingbei (2002) have done a lot of research. Fluid flow experiments were carried out in small channels with different characteristic sizes (0.1 ~ 0.9 mm). The results show that the characteristics of the microchannel flow field are consistent with the Navier-Stokes equations (N-S equation) of viscous incompressible turbulent momentum. The K-ε turbulence model is used to describe the flow in the tiny passage of the emitter (Qingsong et al., 2004).

Figure 3 is one of the typical microchannel emitters, it can be clearly seen from the diagram that the velocity of water flow is greatly reduced by the circuitous structure along the direction of longitudinal irrigation. The transverse staggered tooth structure causes the turbulent flow to produce a violent pulsation, which consumes a huge amount of energy, and blocks the water raft from blocking into water droplets. This kind of energy barrier with interface structure can effectively realize water-saving irrigation in desert area. It makes full use of the hysteresis effect of each drop of water in the process of evaporation and infiltration in sandy soil to ensure the most efficient use of water by plants. The unfavorable effect of volumetric watering on soil oxygen content and waste of excess water are greatly overcome.

**Water molecule infiltrated irrigation materials for self-regulating soil moisture**

In order to overcome the shortcoming of self regulating soil moisture in micro irrigation, an organic – inorganic hybrid material was proposed (Zengzhi & Botaao, 2011; Zengzhi et al., 2011). The superabsorbent resin with strong water-beam ability is compounded with the water-conducting particle with strong water conductivity so that the material of water-permeable chip is prepared. The chipset is installed in the water permeator, and the water molecular water transfer is carried out by using the water potential difference between the material and the soil under the condition of no additional pressure. When the soil moisture is lower than the water potential of the material, the chip accelerates the seepage; Conversely, the speed of seepage slows down. Because this water seepage process is driven by gradient of water potential, the most effective water-saving irrigation is achieved by taking the micro self dynamic structure in dense material structure as medium.

The water-permeating chip consists of superabsorbent resin and water-conducting particles. Since the water-absorbing ability of the water-conducting particles is greater than that of the super-absorbent resin (Du et al., 2015), the water-transfer mode of the water-permeable chip under different water potential states is also different (Lasseux & Valdés-Parada, 2017).

When it is under high water potential (such as high external soil moisture or low external temperature), the three-dimensional network structure of the super-absorbent resin is fully swollen, and the water-conducting particles are completely dispersed. Since the water-conducting particles cannot form a smooth water guiding channel, the chip material mainly conducts water through the dendritic structure of the super absorbent resin, and the speed is slow. When it is under the medium water potential (such as the external soil is dry or the external temperature is raised), the dendritic structure of the superabsorbent resin shrinks correspondingly due to the decrease of the water potential, so that the water-conducting particles are partially “bridged”. At this time, the water-permeable chip conducts water through the dendritic structure of the super absorbent resin and the intermittent clay particle passage, and the water guiding speed is moderate. When it is under low water potential (such as dry soil or high external temperature), the superabsorbent resin shrinks further, so that the water-conducting particles completely “bridge” to
form a continuous and unobstructed water guiding channel. The water-permeable chip is preferentially conducted through the channel of the water-conducting particles, and the water-conducting speed is fast. Through the mechanism of water conduction, the self-regulation of water conduction velocity by water permeating chip under different water potential is realized.

According to the mechanism of water conductivity of water permeable chip materials, large-scale afforestation was carried out in desertified areas (Figure 4). Thus, it is proved that the velocity of water conduction of permeable irrigation is scientific and reasonable. Field application showed that water consumption was only 1/40 ~ 1/60 of traditional afforestation method, while afforestation survival rate was increased by 20%~50%.

**Condensed material for water free irrigation**

The Namib Desert in southwestern Africa has very little rainfall, often with strong winds and large fog in the morning. The desert beetle tilts its body so that its back is facing the wind to collect water, allowing water droplets to flow along the beetle’s back into its mouth. It has been found that the principle of water collection comes from the special hydrophilic alternating concave-convex structure on the back of the beetle (Figure 5). Figure 5(a) is the back of the beetle, with many irregular protuberances. Figure 5(b) is a protruding magnification, The top of the protrusion without wax is very smooth and has strong hydrophilicity, while the surface layer around the protrusion and the bottom layer contain a wax, which is highly hydrophobic. Figure 5(c) shows the surface structure of lotus leaves observed under an electron microscope. The structure consists of a flat spherical sphere arranged in hexagons, so that hydrophobic surface is formed. The surface structure of desert beetles and lotus leaves makes water condensate and is not easily evaporated (Parker & Lawrence, 2001; Summers, 2004).

Ju et al. (2012) found that cactus can collect moisture in the air and eventually form large droplets. A directional groove is formed between the thorn and the barb of the cactus, and these grooves together with the cactus thorn and the bottom tuft constitute a condensation structure (Figure 6). The “deposition” of fog occurs at the bars and main spines of cactus. As the droplets gather and merge, the size of the droplets increases, they then orientate to the base of the spikes and barbs from the top of the spines (Figure 6(a)). The volume of droplets increases as the distance along the gradient grooves increases, cactus absorbs and stores water in this way.

There are two driving factors that cause the directional movement of the cactus droplets, one is the Laplacian pressure gradient along the tapered barbed, the other is the surface energy gradient formed by the roughness gradient along the barbed surface. The Laplacian pressure near the tip of the spike (small radius R1) is larger than near the bottom end (large radius R2) (Figure 7(b)).

In addition to the Laplace pressure gradient, the surface free energy gradient is another driving force for droplet motion. The surface of a cactus has a groove, the groove forms a width gradient across the width, Grooves near the base of the thorns are looser and rougher than those near the top (Figure 7(c)). Since the surface of the thorn of the cactus is coated with wood wax in this experiment, the tip of the thorn is more rough and hydrophilic than the bottom of the thorn, and the surface free energy is smaller.
Figure 6. Morphology of the cactus (Opuntia microdasys) and the structures of a single spine of it.

Figure 7. Illustration of the continuous fog collection and the mechanism underlying.
Bai, Wu, Gong et al. (2015) invented an artificial cactus thorn by means of electrospinning (Figure 8). Using a fine silver needle as the substrate (Figure 8(a)), the artificial fiber was prepared by “winding” the polymer fiber thereon with Electrostatic spinning technology (Figure 8(b)). An artificial cactus fogging device made of this artificial thorn is shown in Figure 9. The artificial cactus is inserted into the sponge ball, and then the water can be collected in a mist atmosphere. The multi-stage groove structure of the artificial thorn surface causes the solid-liquid-gas three-phase contact line to be subdivided in multiples, resulting in a significant increase in the overall Laplacian force of the water droplet. In a foggy environment, water droplets can accumulate at the tip of the needle and migrate to the bottom of the needle. From Figure 8(b) to Figure 9(c), after just 15 min, the volume of water in the graduated cylinder has accumulated from the original 0 ml to 1.3 ml.

**Sand surface crust biomaterials**

Biological crust is composed of living minute organisms and their metabolites (exo polysaccharides) and sand grains under the colonization of desert algae, it is a kind of shell which is formed by the close combination of soil particles and organic matter in the surface layer of soil, it is ubiquitous in deserts or desert areas (Gundlapally & Garcia-Pichel, 2017; Karen et al., 2009). Biological crusts are bound by mycelium, pseudorrhiza, or secreted polyglycans to bind soil particles to form a cushion of active biological crusts.

Artificial biological crust in desert is to promote the formation of biological crust through artificial inoculation of desert algae after the establishment of artificial vegetation in mobile dunes. Or in mobile dunes,
biological and engineering techniques are used to immobilize quicksand, and then biofilm is formed by artificial inoculation of desert algae (Deren, 2009). Biological crust has strong water holding capacity. The water holding capacity of biological crust is 2 times that of subcortical soil (Malam Issa et al., 2001). This high water holding capacity is related to the polysaccharides secreted by cyanobacteria. Because the viscous material secreted by cyanobacteria has the characteristics of water absorption and expansion, the cyanobacteria can absorb water rapidly and increase their volume several times as much as before (Verrecchia, Yair, Kidron et al., 1995; Galun et al., 1982). At the same time, it can withstand the corresponding osmotic water stress and substrate water stress, and has the ability to recover quickly (Durell & Shield, 1993; Kidron & Yair, 1997). This function is of great significance for biological crust to increase soil moisture and rainfall absorption.

Biological crust is a bio-soil-combined complex whose water consumption is mainly soil evaporation and bioevaporation. Biological crust can prolong the retention time of soil surface water (Eldridge et al., 2000), cover the pores of surface soil, and reduce the evaporation of soil moisture. Moreover, the growth of biological crust is mainly to inhibit surface evaporation, and with the increase of development degree, the growth of biological crust gradually changes from inhibiting evaporation to promoting evaporation. Therefore, the relationship between biological crust and soil moisture evaporation needs further study.

Jing et al. (2009) have carried out the experiment of soil surface condensate water under the influence of biological crust in desert area. From April to May, a total of 17 observations of condensate water were made. Condensation occurs almost every day except for strong winds and cloudy rainy days. On cloudy nights, due to cloud protection, the surface temperature drops relatively slowly, so it is not conducive to the formation of condensate. There were significant differences in total condensate amount between different types of land surface (P < 0.01). The total condensate amount increased significantly with the development of biological crust, which showed that: Bare sand < algae crust < lichen crust < moss crust. There was also a significant difference between the mean values of different types of surface condensate water (P < 0.01), and the change trend was consistent with the change trend of total condensate quantity. Biological crust changes the water cycle characteristics and soil stability, soil structure, organic matter content, soil roughness and microtopography of the upper layer of the soil, thus affecting the soil water cycle.

Discussion on the method of desert management

Wetland is an insurmountable ecological barrier for human beings in every desert. Figure 10 shows the Yellow River wetland in Kubuqi. The ecological environment around the desert is very fragile, once dredging the soil, it is easy to cause engineering ecological damage. The ecological environment around the desert is as Figure 11 shows.

Basic approaches and measures

Scientific and rational management methods should be adopted to integrate various technologies of sand fixation, sand control and sand control, such as water conservancy, machinery and ecology, so as to combine sand fixation with sand control,
combine governance with development, and realize one piece of governance, and benefit one piece and beautify one piece.

**Afforestation**

Along the edge of the desert, planted forest belts and segregated forest belts to curb desertification (Figure 12). A layer of green barriers is formed in the desert to prevent the development of desertification. At the same time, in the treatment area, plant grass and planting irrigation, lock sand and fix sand, to improve ecology. Combine the surrounding area with the desert area to achieve both governance and beautification.

**Straw checkerboard barriers**

For reference to the management of Shapotou and Baolan Line in Ningxia from the danger of desert flooding and burying, straw Checkerboard Barriers (Figure 13) are used to prevent wind and sand, to control the sand of water conservation, and to use wheat straw, reed and other materials to set up a grid windshield wall on the mobile sand dune to weaken wind erosion.

This method can increase the roughness of the surface and weaken the wind speed of the near-surface layer. The first reflection of the change of the properties of the underlying surface is the increase of...
the roughness of the ground, the reduction of the wind force and the retention of water, such as Rain Water, so that the water content in the sand layer is increased, which is beneficial to sand fixation. The sand-fixing sand barrier has high cost of sand fixation and is laborious, but it is very effective for sand fixation and plant survival.

Many measures are taken simultaneously to prevent sand. First lock "sand source", and then proceed with calm management, gradually develop and beautify the environment. In the control area, using mechanical sand fixation technology to obtain materials (such as wood grass, stone, etc.) to build sand barriers to slow down the flow of sand dunes, so as to gradually stabilize the desert.

For fluidity and hazardous areas, chemical sand fixing agents are sprayed to achieve sand fixation and reduce wind erosion. In the area of governance, sandy plants (such as licorice, ephedra, sand dates, sea buckthorn, sand willow, etc., Figure 14) with economic value and practical value are planted to establish a sand reserve. The area integrates vegetation restoration, economic development, landscaping, and wildlife protection, so that it can be managed, beautified and profitable in the same time.

Figure 15 shows that desertification control workers are planting trees with spiral drilling method. This method is suitable for planting trees in areas with low water level in the desert, and the survival rate can

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Figure 14. Sand binding plant.

Figure 15. Desertification control workers are planting trees with spiral drilling method.
reach 65%. In China, Yili Group has built more than 240 km of sand-control and river-protection border-locking forest belt along the southern bank of the Yellow River, effectively curbing the spread of desertification, and at the same time, it can reduce the invasion of hundreds of millions of tons of yellow sand into the Yellow River every year.

**Conservation of water and soil**

In order to fully exploit the use of flood resources and underground and surface water resources, water is used to change sand. In the mainstream area of the desert, sand dams and diversion channels are built to bring flood into the hinterland of the desert, and silt up the fields. This is to prevent soil erosion and open up a large number of fertile fields, expand cultivated land and turn flood into profit.

**The development of desert economy is in keeping with the production management and development of agriculture and animal husbandry**

Take the road of governance combined with vegetation construction, landscaping, wildlife protection and so on. Develop economic plant planting, animal breeding, processing of sandy land resources, and tourism in the sandy land. At the same time, the modern agriculture and animal husbandry in sandy land will be developed in a planned way by using modern water-saving irrigation technology in combination with water and silt conservation fields and sand conversion to further transform the desert and beautify the environment in production and economic development.

**Building roads to green the desert**

In China, Yili borrowed 75 million yuan to build 65 km of “sand driving roads” in the Kubuqi desert, shortening transportation distance, reducing costs, increasing corporate profits and improving development capacity (Figure 16). Highway construction forms a hidden vegetation belt of 230 km² across the Kubuqi desert, which changes the landscape of the Kubuqi desert and makes the original single vegetation and fragile ecological landscape on both sides of the highway become diversified. At the same time, the ecological environment of the highway construction has also been transformed. In the development of the desert hinterland, not only the economic and social benefits have been obtained, but also the ecological benefits have been improved. The roadbed and sand barrier on both sides of the road changed the ecological environment to improve the water conditions. The vegetation was mainly changed from the original xerophytes to the middle plants. Therefore, it also creates a suitable environment for the habitat and settlement of animals and plants, and also creates conditions for the natural control of sand areas.

**Intensive utilization of desert land**

On March 20, 2008, the Yellow River in the city of Hangguoqi, Ordos City, was destroyed by the Yellow River. More than 100,000 people were affected by the disaster. The people in the disaster area had a hard time with the joint efforts of the government and the community. The government planned the new town and moved to the edge of the Kubuqi Desert to build the city. This has guaranteed the property security of the people and saved the land to lay the foundation for the sustainable development of agriculture.

The new site is located on the edge of the desert and is ecologically fragile. It is firmly locked by the urban construction. The new town is adapted to local conditions. During the construction of the house, the desert is also emphasized. The reasonable vegetation cover is planned, the environment is beautified and the ecological environment is improved. An ecological town is full of life, the beautiful town is decorated with desert, and the surrounding green belt brings people fresh and healthy. Subsequent construction of the investment promotion project has made full use of the desert
edge desert land, saving the ploughing zone and stimulating economic development.

The introduction of Erdos Linzhongdi Agricultural Development Company and Shahai Edible fungus Co., Ltd. has made Huangsha a driving force for economic growth, and a thousand mu desert has been effectively utilized. A series of economic construction has utilized the desert, and the desert has been greened and managed while achieving economic benefits. This is a beautiful beginning for new ideas and new periods.

**Study on new greening technology**

In this section, new Greening Technology is discussed with the example of Kubuqi sand area in China.

In China, Kubuqi Sandy District covers an area of 11,500 square kilometers, accounting for 61% of the total area of Hangzhou Banner (a place name). The forest area is 2689 square kilometers, the forest coverage rate is only 14.6%, and the cost of afforestation is much larger than other areas.

In order to effectively solve this problem, Hangjin Banner has always attached great importance to and actively adopted the deep pit planting and topping afforestation (afforestation before the melting of frozen soil), and introduced and promoted drought-resistant water retention agent and ABT rooting powder. Combined with the afforestation techniques such as container water afforestation, rainy season afforestation, cold seedlings anti-seasonal afforestation and windward slope shrub dense planting and afforestation, the survival rate of afforestation is greatly improved.

**Water retaining agent for drought resistance**

It is also known as soil moisture retaining agent, anti-transpiration agent, fertilizer storage agent or micro-reservoir, is a unique three-dimensional network structure of organic polymer. It can absorb and retain rainwater or irrigation water rapidly in the soil, change it into solid water without flowing and seepage, and keep local constant humidity for a long time. Its unique water absorption, water storage and water retention performance play a decisive role in improving the ecological environment and wind and sand fixation projects. It is widely used in land desertification control, agriculture and forestry crop planting, landscaping and other fields. It is recognized in the world as the most effective micro-water irrigation supplies for drought resistance and moisture conservation, which saves a large amount of irrigation water and water conservation labor for the society.

**ABT rooting powder**

It is a broad-spectrum, high-efficiency and compound plant growth regulator. It can promote rooting, shorten rooting time, improve rooting rate, and make the difficult-to-root tree species succeed in cutting propagation. Its effect is superior to indobutyric acid (IBA) and naphthalene acetic acid (NAA). Afforestation can increase emergence rate, preservation rate and increase growth. By soaking seeds, spraying seeds or plants, and treating tubers or roots, a series of physiological changes have taken place in seedlings of various crops, so as to improve seed germination potential and germination rate, accelerate vegetative growth, make roots deep and leafy and make crops develop vigorously, improve or increase spike (plant) grains, or increase 1000-grain weight or Increase the growth of roots, stems, flowers, fruits, and so on, thereby increasing crop resistance and crop yield.

**Conclusion and policy implications**

Desert as a branch of geography and related disciplines of soil and water conservation. It should be said that material science has not been systematically regarded as an important means of desert control engineering technology in the long term research. The transfer function, interface function and storage function of the material have attracted people’s attention in recent years. The complete restoration of sandy soil to its original cultivated land level is a long process in the field of ecological restoration, and requires input of material, energy and scientific information to the sandy soil. But the restoration of this ecosystem is centered on scientific water.

From the current research, desert water science materials are still in the initial stage. The large amount of equipment and material wastage and the difference between water consumption and plant demand of micro-irrigation technology seem to be attracting more and more attention; The bionic condensation material also stays in the exploration stage of the laboratory; Biofilm technology has a positive effect on sand fixation, but the amount of condensate water needs further breakthrough; Strong absorbent materials represented by superabsorbent polymers were developed and used in seed coating and compound fertilizers, people do their best to avoid their reverse water absorption problem to the roots of plants; Porous mineral materials have also been developed and applied in deserts.

The future development of desert water science materials is mainly reflected in the following six aspects:

1. The molecular permeation irrigation material that self regulates soil moisture is further refined and intelligentized to achieve optimal combination of water saving, ecology and economy;
(2) The development of functional materials for water condensation, storage and controlled release can achieve breakthroughs and scale up for desert production;
(3) The distribution and utilization of desert surface water have aroused great concern, and some new water-oriented functional materials can be developed and applied;
(4) Some water science composite technology or multifunctional composite technology can be integrated and developed;
(5) More emphasis is placed on the design of water science materials for different sites in the desertification environment, such as sand tables, plant roots, seed appearance and leaf surface, etc. Different water science material principles and methods are required;
(6) Water science material technology based on environmental conditions such as desert climate, surface water potential difference, salt difference and temperature difference will open up new fields for research.

The desert water science material is a scientific proposition put forward under extreme desert water shortage conditions. Its fundamental task is to inhibit the desertification process and achieve effective ecological restoration. Therefore, the new material technology of “waterless irrigation” and “smart irrigation” will be the dominant direction of future development.

However, sand control is the most fundamental solution. In a word, take the road of governance combined with vegetation construction, landscaping, wildlife protection, and so on. Develop economic plant planting, animal breeding, processing of sandy land resources, and tourism in the sandy land. At the same time, the modern agriculture and animal husbandry in sandy land will be developed in a planned way by using modern water-saving irrigation technology in combination with water and silt conservation fields and sand conversion to further transform the desert and beautify the environment in production and economic development.

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