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Applications of Smart Materials for Flow Control in Agriculture

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ABSTRACT

Agriculture is the largest consumer of water and the total evapotranspiration from global agricultural land could double in the next 50 years or so, if the current practices in food production and consumption continue. There is an increased need for improved water management due to spatial and temporal variability in rainfall and drought/water scarcity being a constant threat in our nation.[dx.doi.org/10.4172/2155-6199.1000315] The existing methods of irrigation include sprinkler irrigation, flood irrigation and drip irrigation. Among which drip irrigation is proved to be the most efficient when it comes to water management (efficiency ~80%)[PP 2265-272], but the problems associated with such a practice is that it requires monitoring and since the wetted area is much smaller when delivered by drip, control is more critical in application of water to avoid plant stress. To counter such problems various smart materials are used, one such smart material called Hydrogels are utilised in this project. Hydrogels are hydrophilic cross-linked polymers that form three dimensional molecular networks which can absorb and hold great amounts of water.[ISSN -00975-1491] These hydrogels are used to design and fabricate a special valve for improved flow control in agriculture.

Keywords: Hydrogels, gel formulation, smart materials, special valve water management, flow control, drip irrigation.

1. INTRODUCTION

Agriculture is the dominant global user of freshwater, accounting for nearly 70% of consumptive use. The National Commission for Integrated water resources Development (NCIWRD) estimates total withdrawal/utilization for the year 2010 for all types of uses as 710 BCM for high projection (BCM- Billion Cubic Metre), whereas, for the year 2050; total 1180 BCM has been estimated for high projection scenario. Out of which irrigation will be accounted for nearly 68% followed by domestic use 9.5%, industries 7%, power development 6% and other activities claimed about 9.5% including evaporation losses, environment and navigational requirements. When it comes to agriculture, there is an increased need for water management in India due to poor ground quality (saline/brackish); Deterioration of soil health in the intensively cultivated areas; Low rainwater use efficiency. The overall efficiency for surface water system is 30-65% and for ground water system is 65%

1.1. Literature Survey

The innate ability of poly(N-isopolyacrylamide) hydrogel to co-polymerize and to graft synthetic polymers and biopolymers in conjugation with the highly controlled methods of radical polymerization these hydrogels are extensively investigated for applications on the controlled delivery of active molecules, inn self healing materials, tissue engineering, etc[1].The concept and measurement of ‘water use efficiency’ and ‘water productivity’ as applied at farm, region/sub-basin, basin and national level through traditional and based sensing estimations[2]. A brief information regarding the manufacture and the types of hydrogels, study on the swelling nature of the hydrogels and their current applications [3].

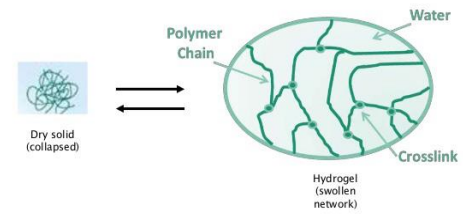
From all these papers we have obtained the understanding that, there is an increased need for water management in the agricultural sector and several smart materials and the innovations involving them can be utilized for efficient water use. One such smart material that we consider in our project is hydrogels and a special valve is designed for improved water management.

Hydrogels are the major raw material considered for this project. They are hydrophilic cross linked polymers that form three-dimensional molecular networks which can absorb and hold great amounts of water. The first step of the project is to study the various properties of this smart material such as swelling behaviour, elastic modulus, retention time, etc. The next step is to fabricate the valve based on the study made and use it for irrigation applications for improved usage of water.

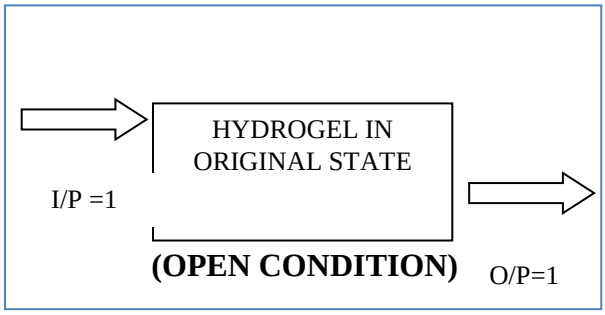
2. MATERIALS AND METHODS

The objectives of the project include 1) Applications of smart materials for flow control in agriculture; 2) Design of special valve using hydrogels; 3)Trials of smart materials using designed valve; 4)Study of controlled release of nutrients in gel formulation. Hydrogels are the major raw material considered for this particular project. Hydrogels are hydrophilic cross-linked polymers that form 3 dimensional molecular networks which can absorb and hold great amounts of water. Different types may be suitable for agricultural use, starch based is biodegradable and cheap, and can be modified to adjust its ability to hold water. Cross linked acrylic acid polymer hydrogels are commercially available.

Fig.No.1 EFFECT OF WATER ON HYDROGEL

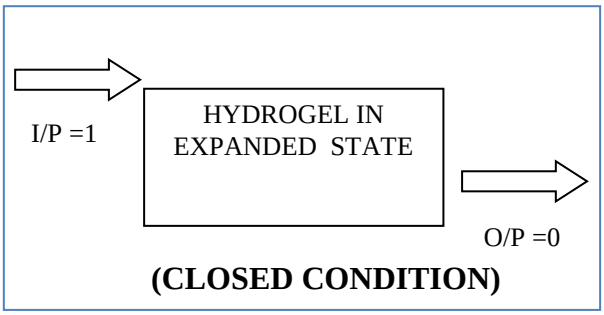


The first step of the project is to study the various properties of hydrogels such as retention time; swelling behaviour; amount of water absorbed, using basic testing methods. The next step is designing a special valve using hydrogels. A very basic schematic diagram of the valve is as follows:



As you can see from the above diagram, a porous case containing the hydrogels is buried under the soil next to the necessary plants. In open condition, ie., at initial stages the hydrogels would possess its normal structure and therefore there is no obstruction to the flow of water.

As the water level increases beyond the desired level, the excess water is absorbed by the hydrogels, thus moving the piston placed above it. This way, the flow of water reduces and if needed, the flow of water can be entirely restricted using the same mechanism. This is represented by the closed condition diagram



The final step of the project is to study the controlled release of nutrients in gel formulation. Urea is an organic compound that is produced by live organisms and also is one of the most important sources of nitrogen for plants, so the study of urea release from hydrogels is useful for both pharmaceutical and agriculture applications Hydrogels Based on Acrylamide, Methyl Methacrylate And N,N'–Methylene–Bis–Acrylamide methacrylate is combined with more hydrophilic monomers in order to improve mechanical properties and for inducing to the polymer the ability to swell in organic liquids. The hydrogels that are able to swell in both water and organic are known as amphygels. Methyl methacrylate is a hydrophobic monomer with many applications in polymer industry but of limited use in hydrogels synthesis due to its low water absorption, however MMA has been copolymerized with acrylic acid, methacrylic acid and other monomers in order to produce hydrogels with good mechanical properties.[4]

3. RESULTS AND DISCUSSION

Non biodegradable hydrogels are used

1. Small scale design was made using 20ml syringe
2. The model (in open condition) is filled with hydrogel (1g) was placed in a beaker of water (400ml)
3. Rise of the piston due to the expansion of hydrogels were noted
4. The model (closed condition) was placed in dry red soil & the drying rate was noted
5. Agricultural grade hydrogels are tested
6. Soil type sand soil red soil

4. CONCLUSION

The potential of hydrogels are not completely explored yet. The special valve, used for the flow control in agriculture is first of its kind. Such an approach has never been done before. It is estimated that the use of hydrogels in agricultural fields improve the water use efficiency by 60%. It is expected to increase even more from this particular approach. Hydrogels are commonly used for controlled drug release systems; the same principle can be utilised for the controlled release of nutrients in agriculture with certain required modifications. The success of this control valve will also yield the better use of fertilizers in future.

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