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Research Article

STUDIES ON SOIL PH, SALINITY, AND MOBILITY OF CAT IONS; MOISTURE AVAILABILITY IN THE SOIL OF BANANA USING TREATED BOARD MILL EFFLUENT

C. PRABAKARAN*
Department of Natural Resource Management, Horticultural College and Research Institute for Women, Trichy, 620027, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India
*Corresponding Author: Email - prabakaran.c@tnau.ac.in

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Abstract: The field experiment was conducted at ITC Green Belt Greenery situated at Thekkampatty Village, Coimbatore District to evaluate the influence of drip fertigation through treated board mill effluent on nutrient mobility and moisture availability. The results of the study revealed that the moisture content was high in the surface layer near the emitter and the salts were concentrated towards the periphery of the wetting front. The exchangeable Na below the emitter was less and increased at the periphery of the wetting front, due to its mobile nature, which in turn reduced the stress from effluent irrigation.

Keywords: *Drip irrigation, Surface irrigation, Fertigation, Banana, Nutrient*

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Introduction

The United Nations' Sustainable Development Goal 6 emphasizes the importance of reusing treated wastewater to ensure water availability for everyone. Utilizing treated wastewater for crop irrigation is a practical solution, considering that the agricultural sector is the largest consumer of water resources. Use of wastewater for irrigation influence on its environment. Wastewater irrigation has a valuable contribution as a fertilizer after treatment [1]. Furthermore, it has environmental consequences of wastewater irrigation on both soil and plants.

Efficient water management and sustainable agricultural practices are vital for ensuring food security and preserving natural resources. With the increasing scarcity of freshwater resources, the reuse of treated wastewater has emerged as a viable solution to meet the growing water demands in agriculture. This study focuses on the utilization of treated board mill effluent for irrigation and its impact on soil properties, moisture availability of banana crops.

The use of treated wastewater for irrigation offers a dual advantage by conserving freshwater supplies and providing essential nutrients to crops. Board mill effluent, after undergoing appropriate treatment processes, can serve as an alternative water source for agricultural irrigation. However, it is crucial to assess the effects of such irrigation practices on soil health and crop productivity to ensure the sustainability of this approach.

This study aims to investigate the influence of treated board mill effluent irrigation on several key factors, including soil pH, salinity, and the mobility of cat ions. Soil pH plays a significant role in nutrient availability and microbial activity, which directly impact plant growth and development. Salinity, on the other hand, can affect soil structure and reduce water uptake by plants. Understanding the effects of treated effluent irrigation on these soil properties is essential for making informed decisions regarding its long-term use in agriculture.

Furthermore, the study will assess the moisture availability in the soil under-treated effluent irrigation. Adequate moisture levels are crucial for plant growth and the efficient uptake of nutrients. By evaluating soil moisture content and its distribution, we can determine the effectiveness of treated effluent irrigation in maintaining optimal soil moisture levels for banana cultivation.

Understanding the implications of utilizing treated board mill effluent for irrigation purposes will contribute to the knowledge base on sustainable water management and agricultural practices. The findings of this study will provide valuable insights for policymakers, farmers, and researchers aiming to promote efficient water use and maximize agricultural productivity in regions facing water scarcity challenges.

The analysis of existing literature indicates that inadequately treated wastewater leads to the accumulation of heavy metals and other toxic elements in soils and plants. It also highlights the increased levels of pathogens, posing risks to human and animal well-being. The long-term impacts of emerging contaminants should be established in future studies because these are generally new chemicals and there are no standard analytical techniques to precisely detect and analyze them. Similarly, the reliable long-term comprehensive appraisal of heavy metals' threat to human health needs to be explored in future investigations.

The effluent-producing industries need eco-friendly and economically viable technologies for recycling their solid and liquid wastes. Land application of wastes has been preferred as an alternative for safer disposal. Indiscriminate surface application of industrial effluents has harmful effects on crop yield, soil and groundwater quality [2,3].

Drip irrigation is a hi-tech, efficient and potential method in modern agriculture that results in higher yield and improved quality of the crop produced. Fertigation is a technique that combines fertilizer application with any micro-irrigation system, especially through drip irrigation. The fertigation technique makes it possible to irrigate and fertilize over a large area in a more uniform and efficient manner. Soluble fertilizers can be applied directly to the root zone, in accordance with the crop needs at different growth stages on a more scientific basis. Besides economizing the water and fertilizer, it also saves labour towards weeding, fertilizer application and irrigation [4]. In drip irrigation moisture was always higher and uniform in the root zone than with furrow irrigation [5]. In contrast, there was two-dimensional distribution of soil moisture in a wine yard resulting in a drip irrigation method with moisture content high along and beneath the row and decreasing laterally.

Soil water distribution in both, 0 to 0.15 and 0.15 to 0.30 m depths was uniform under drip-irrigated apple plants and decreased as the soil depth and distance from the dripper increased [6].

Employing a slow and frequent watering approach in drip irrigation systems effectively minimizes significant fluctuations in soil moisture levels, thereby fostering improved growth and yield outcomes [7]. Bharambe *et al*. (2001) [8] reported that higher water content was found below the dripper and it followed a decreasing trend with increased spatial distance, lateral as well as vertical. Irrigation at 0.8 and 1.0 ETC maintained moisture content near field capacity.

Materials and methods

A split plot design was adopted with two replications. There were seven main plot treatments and three subplot treatments. In the main plots, irrigation sources *viz*., treated paperboard mill effluent and river water were applied through fertigation and surface application along with farmer's practice (river water surface irrigation with 100% NPK) as control. Treated paperboard mill effluent after filtration was fertigated through drip irrigation with 75 and 50 percent NK and in effluent basin irrigated plots, 100 and 75 percent N and K were given as band application. The amendments *viz*., fly ash and bio-compost were applied either alone or in combination with green manure in subplots. The banana variety Robusta was raised as a test crop and the observations were made on mobility of moisture and cat and an ions. The results obtained from this present investigation are summarized and the following conclusions were drawn.

Profile study in the effluent fertigated soils indicated that the moisture content was high in the surface layer near the emitter and the salts were concentrated towards the periphery of the wetting front. The exchangeable Na below the emitter was less and increased at the periphery of the wetting front may be due to the mobile nature of Na in the water, which in turn had decreased the stress in the banana plant due to effluent irrigation [9].

In this present study, the fertigation treatments were significantly superior in improving the soil properties and protecting the groundwater from effluent basin irrigation hazards and combined the application of amendments improved the soil properties and groundwater quality. This indicated that fertigation could be adopted for industrial effluents like paper etc., along with the recycling of paper mill wastes along with green manure.

Results and discussions

Moisture availability and nutrient mobility under fertigation

Higher soil moisture content (16 percent) was recorded near the emitter of effluent fertigation at 0 to 15 and 0 to 30 cm depths. The moisture content was found to decrease with an increase in depth and distance away from the emitter. Lower moisture content (10 percent) was recorded at 75 to 90 cm depth and 40 to 100 cm away from the emitter [Fig-1].

The soil moisture content under basin irrigation at different time intervals and at different depths ranged from 10 to 16 percent. Moisture content immediately after irrigation was uniform throughout the soil profile. At the top layer, the moisture content decreased with an increase in time but at the deeper layer, the moisture remained at a higher level.

The distribution of water is very important for crop management. In general, the yield of most of the crops is not affected as long as the water supply remains above 65 percent of the available water on loamy sand. Data on soil moisture content are depicted, which reveal that the moisture content was higher near the dripper and decreased with the increasing lateral distance from the emitter. Similarly, it was higher in the surface layer (0-15 cm) and subsurface layer (15-30 cm) and followed a decreasing trend with the depth. Similar observations were recorded by Bharambe *et al.* (2001). They also reported that the moisture content under surface irrigation treatment followed an increasing trend with the soil depth. Singh et al. (1978) reported that a significant gradient in water content existed from the point of application to the wetting front.

Higher pH values were recorded near the emitter. The pH of the soil was found to decrease towards an increase in distance away from the emitter and depth. The pH of the soil just below the emitter was increased and decreased towards the wetting front. Similarly, the pH decreased towards the increase in depth [Fig-2].

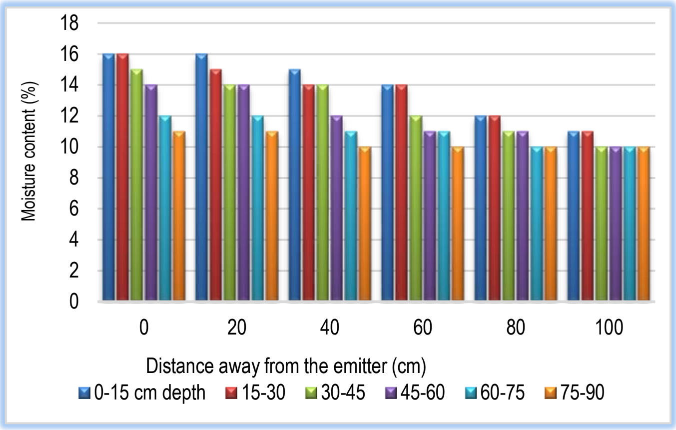

Fig-1 Effect of effluent fertigation on moisture distribution in the soil

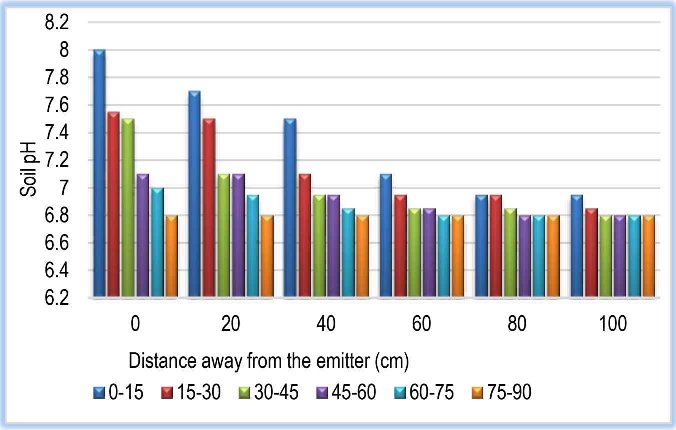

Fig-2 Effect of effluent fertigation on soil reaction in the profile

The lower salt content (EC) was recorded immediately below the emitter and found to increase towards an increase in distance away from the emitter and the higher EC was recorded at 80 to 100 cm away from the emitter. There was no salt accumulation in the soil profile due to an increase in soil depth. The soil pH and EC under drip irrigation of the effluent varied from 6.80 to 8.00 and 0.02 to 3.19 dS m-1, respectively [Fig-3].

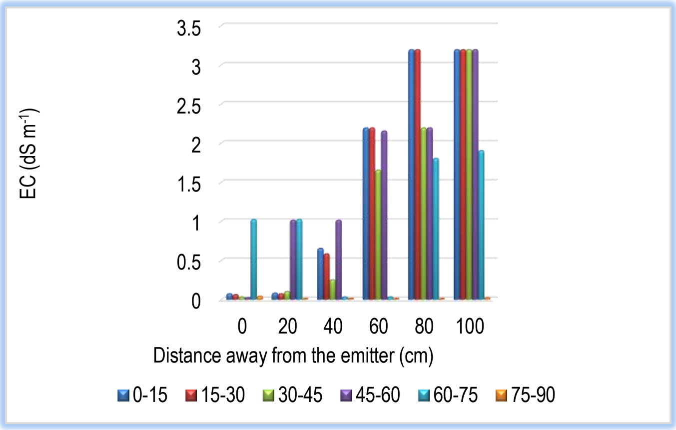

Fig-3 Effect of effluent fertigation on salinity in the soil

The spatial distribution of salts as affected by the fertigation of effluent showed that the soil salinity was a minimum below the emitter. This might be due to the continuous movement of salts with waterfront away from the emitter.

The soil exchangeable Ca and Mg under drip irrigation of the treated effluent varied from 0.10 to 9.50 and 0.35 to 5.70 cmol (p+) kg-1 respectively [Fig-4] Higher exchangeable Ca was recorded immediately below the emitter and the values were found to decrease towards an increase in depth and distance away from the emitter. The lower exchangeable Ca was present in 75 to 90 cm depth. Exchangeable Mg was also found to decrease towards an increase in soil depth. In the surface layer, higher values were recorded at 60 cm away from the emitter.

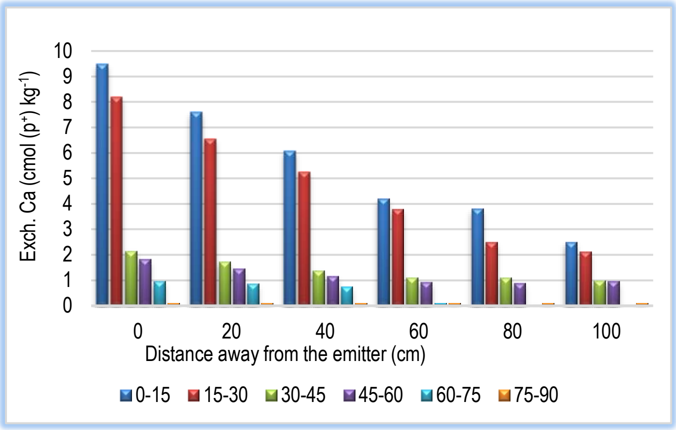

Fig-4 Effect of effluent fertigation on exchangeable Ca in the soil

Lower exchangeable Na content was recorded immediately below the emitter. It was found to increase towards an increase in distance away from the emitter and higher values were recorded at 80 to 100 cm of the surface layer. The CEC of the soil was found to decrease towards an increase in soil depth but it does not show any variation due to an increase in distance away from the emitter. Higher CEC value was recorded in the surface layer and a lower value was recorded in the lower layer. The soil exchangeable Na and CEC recorded under drip irrigation of the effluent ranged from 0.01 to 3.5 and 1.5 to 13.7 cmol (p+) kg-1, respectively [Fig-5].

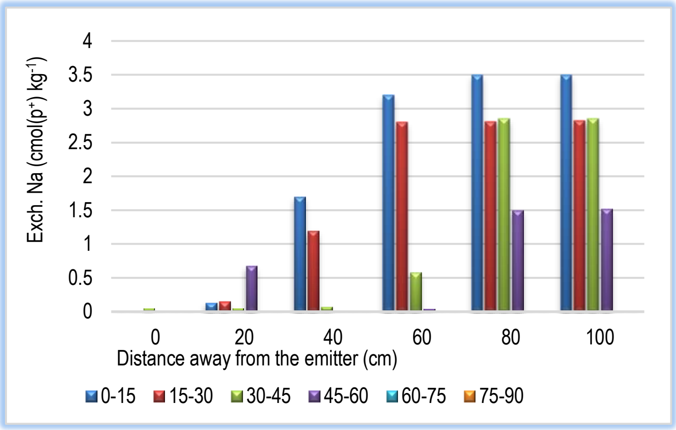

Fig-5 Effect of effluent fertigation on exchangeable Na in the soil profile

The chloride concentration just below the emitter recorded lower values and continued up to 60 cm distance and increased afterward and higher values were recorded at 80 to 100 cm away from the emitter. In the soil profile, higher values were recorded at 49 to 75 cm depth. Similar observations were recorded in sulphate concentration also.

Recycling of industrial waste for crop production is gaining importance in recent times. Indiscriminate surface application of industrial effluents had harmful effects on crop yield, soil, and groundwater quality. In order to develop an ameliorative approach to nullify the ill effects of these effluents and to restore the ecosystem, an attempt has been made to assess the impact of effluent through drip irrigation and soil addition of solid wastes/amendments on the soil-water-plant ecosystem. Certain facts emerged from the study, which clearly indicated that the harmful effects could be minimized by fertigation and the application of suitable amendments.

The availability of N and P at different depths below the emitter at harvest was determined and the results envisaged that the availability of N and P was maximum at 0-15 cm depth and decreased with the depth of the soil profile. The accumulation of available P in the surface layer might be due to less mobility of P in the soil. Similarly, the available K was maximum in the surface layer might be due to the entrance of K ions on the soil exchange complex restricting the movement of K to deeper layers. Organic carbon was also increased at the surface layer but there was no difference in the movement and accumulation away from the emitter.

The Ca content was decreased with an increase in depth. This might be due to the immobility of Ca ions in the soil. The Mg content was high in the surface layer and decreased with increasing depth. The exchangeable Na below the emitter was less and increased at the periphery of the wetting front. This might be due to the mobile nature of Na in the water. The exchangeable K content was high below the emitter and it decreased when the distance away from the emitter increased. A similar observation was recorded by Mohamedharoon (1991) [10]. Cation exchange capacity at the surface was high and it decreased towards an increase in depth but it did not have variation due to drip irrigation.

Conclusion

The results of the study revealed that the moisture content was high in the surface layer near the emitter and the salts were concentrated towards the periphery of the wetting front. The exchangeable Na below the emitter was less and increased at the periphery of the wetting front, due to its mobile nature, which in turn reduced the stress from effluent irrigation. Hence the effluent irrigation after treatment and pucca filtration should be used for banana crop to protect the soil water and air environment in and around the factory

Application of research: Research on soil pH, salinity, cation mobility, moisture availability, using treated board mill effluent provides valuable insights into the benefits and challenges of using industrial wastewater for irrigation. These studies help assess the impact on soil acidity, nutrient availability, and plant health, as well as determine the salinity levels and water-holding capacity, enabling informed decisions on sustainable wastewater reuse in agriculture

Research Category: Natural Resource Management

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University: Tamil Nadu Agricultural University, Coimbatore, 641003, India
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Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: ITC company Mettupalayam

Cultivar / Variety / Breed name: Robusta

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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