



## **Conference proceedings**

10th International Micro Irrigation Conference (10IMIC) on the Topic

**Micro-irrigation in the Era of Technology Innovation and Digital Transformation**



**10ème Conférence Internationale de la Micro Irrigation sur le Thème**

**La Micro-irrigation à l'Ere de l'Innovation Technologique et de la  
Transformation Digitale**

**25-27 Janvier 2023**

**Centre de Conférences - Dakhla Maroc.**

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## Préambule

La 10e Conférence internationale sur la micro-irrigation, qui a été placée sous le Haut Patronage de Sa Majesté le Roi Mohammed VI, que Dieu L'Assiste, s'est tenue à Dakhla, au Palais des congrès, du 25 au 27 janvier 2023, sur le thème de la micro-irrigation à l'ère de l'innovation technologique et de la transformation numérique. Elle a été organisée par l'ANAFIDE, Comité national marocain de la Commission internationale des irrigations et du drainage (CIID), en collaboration avec le Conseil de la communauté marocaine à l'étranger (CCME), en partenariat avec la CIID et avec le soutien du Ministère de l'Agriculture, de la Pêche Maritime, du Développement Rural et des Eaux et Forêts. Parmi les partenaires scientifiques associés à l'ANAFIDE pour l'organisation de la conférence figurent l'Institut international de gestion de l'eau (IWMI), trois projets PRIMA de l'Union européenne, la Commission internationale du génie rural et des biosystèmes (CIGR), l'Institut international des hautes études agronomiques et méditerranéennes (CIHEAM-BARI) et l'Institut international de recherche sur l'eau (IWRI) de l'UMP6. La séance d'ouverture a été présidée par M. Redouane ARRACH, Secrétaire général, du Ministère de l'Agriculture, de la Pêche Maritime du Développement Rural et des Eaux et Forêts. Lors de son mot de bienvenue aux participants, le Président de l'ANAFIDE, Mr Aziz FERTAHI, également Vice Président Honoraire de la CIID, a exprimé ses vifs remerciements et son immense gratitude à SM le Roi Mohammed VI que Dieu l'Assiste pour avoir accordé son Haut Patronage Royal à cette conférence. Il a également remercié Mr Le Ministre de l'Agriculture, Dr SADIKI Mohamed, Président du Centre international de Hautes Etudes Agronomiques et Méditerranéennes (CIHEAM), et Mr le Secrétaire Général du Ministère de l'Agriculture, les autorités locales, les partenaires de l'ANAFIDE, notamment Mr Ahmed BOUARI, Directeur de la Direction de l'Irrigation et de l'Aménagement de l'Espace Agricole, Vice Président Honoraire de la CIID et Président du REMIG, les délégations étrangères et les organismes publics (notamment ORMVA et DRA) et privés pour leur collaboration et soutien.

Lors de la séance d'ouverture, des mots de bienvenue et des interventions ont également été prononcés par :- Monsieur le Secrétaire Général Adjoint de la Wilaya de Dakhla Oued Ed-Dahab, - Monsieur le Vice-Président du Conseil de la Région de Dakhla-Oued Eddahab, Dr Mohammed BENSALAH, Représentant Mr Le Président du Conseil de la Communauté Marocaine à l'Étranger (CCME), - Monsieur le Président de la CIID, Dr Ragab RAGAB, - Monsieur le Président du Conseil Mondial de l'Eau, M. Louis FAUCHON (intervention en ligne).

En outre trois side events ont été organisés en parallèle à la conférence: (i) un workshop d'une demi journée coordonné par le Dr Youssef Brouziyne Directeur du Bureau Régional de l'IWMI au Caire, sur le thème « Catalyse du développement durable par des projets d'eau non conventionnels ». (ii) Un workshop d'une demi journée coordonné par les représentants des projets PRIMA, SUPROMED, PRECIMED et MEDWATERICE, sur le thème: Agrosystèmes méditerranéens : Micro-irrigation et défis des économies d'eau. et (iii) un side event d'une journée coordonné par Dr Mohamed BENSALAH du CCME, le 26 janvier, sur le thème « Nexus Eau, énergie et alimentation ». Des enseignants chercheurs issus de plusieurs Grandes Universités marocaines et étrangères et Instituts ont également participé à la conférence. De même plusieurs sociétés privées importantes intervenant dans les études, la fabrication et distribution des équipements et matériels d'irrigation ou dans les aménagements hydro agricoles membres du réseau REMIG ont participé à une exposition de matériel et ont apporté un appui financier précieux à l'ANAFIDE . Le présent document proceedings n'est pas exhaustif car il ne couvre pas les activités des side events de la conférence et ne contient que les résumés que les auteurs remerciés ont bien voulu envoyer au comité d'organisation.

Pr El Houssine BARTALI, Coordonnateur scientifique de la Conférence-Vice Président de l'ANAFIDE

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# Investigating the current extent of new technologies use in irrigation water management in the Nile Delta-Egypt

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## Abstract

Today, feeding more than 106 million is one of the significant challenges for the Egyptian government. Under the changing climate, challenging water scarcity and salinity have negative impacts on food availability. Effective water management is paramount to increase food productivity in Egypt and all MENA countries where food and water security and key. For this objective, the new advances in technologies offer large room for improvement in crops and their environment management. This study was conducted to assess water management in the agricultural sector in the Nile Delta, Egypt, with the aim of understanding the current situation for modern technology applications. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were adopted. Based on the relevant literature of “Egypt” AND “irrigation” AND “Nile Delta” OR “Old land” OR “Drainage” OR “modern irrigation” OR “drip” OR “sprinkler” OR “furrow” OR “technology” OR “Smart” OR “Digital” OR “sensor” OR “IoT” OR “agrometeorology” OR “agro-meteorology” in Elsevier, Springer, Scopus, and Google Scholar. A total of seventy-seven articles were obtained from 2015 to 2021. The result showed that 47% of the reviewed articles focus on improving the mapping techniques, using recent remote sensing data and GIS, 21% on Agrometeorology, 21% on modeling and simulation, and 11% on solar energy. Only 5% of the selected articles covered sensors and IoT-related applications. In terms of scope of technologies, 32% of the reviewed technologies are monitoring water, while 28% are focusing on soil, 21% on climate, and 18% are for plants. The study recommended paths for research and development to increase the number of studies focused on sensors and IoT systems for saving water usage in irrigation processes.

Keywords: Nile delta, irrigation, technologies, water management, crops productivity

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## **Status-quo, Opportunities and Challenges of Irrigation in Morocco: A Critical Analysis based on a Comparative Study.**

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**Abstract :** Morocco is undergoing rapid change driven by population growth, increased food demand, water stress, urbanization, new market opportunities, and climate change. Due to climate variability, Morocco faces significant climate risks, including the reduction of rainy days, shortened growing seasons, changes in soil moisture levels, frequent and more intense droughts, increasing mid-season dry spells, flash floods, and rising temperatures. Without efficient irrigation systems, low quantity and quality yields, crop damage and even loss, and low incomes are more likely to be observed. In this paper, a critical analysis was conducted based on a comparative study about opportunities and challenges of irrigation in Morocco and attempt to fill the knowledge gap in understanding the opportunities and challenges of implementing efficient irrigation systems in Morocco. A systematic literature review (SLR) is performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Qualitative studies used four main databases, such as, Science Direct, Scopus, Web of Science and Springer Link. Also, data was collected through desk reviews to assess the status, challenges, opportunities, and future perspectives of irrigation investment. The assessment was conducted based on three pathways: farming irrigation, micro-irrigation scheme development and modernization, and wastewater reuse. The findings of this study would

be an important input for future research, decision makers, and pave ways for the implementation of integrated water resources management.

Keywords: Micro-irrigation., Integrated water resources management., Climate change., Systematic literature review., Morocco.

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## **Modernization of irrigation systems: Collective reconversion to drip irrigation in El Haouz area (Analysis and Lessons)**

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**Abstract:** Because of the actual situation of the succession of drought's years, the increase of water scarcity and competition between sectors (agriculture, industry, and drinking water), the economy and valorization of irrigation water are presented as two important objectives in the water policy in the world and specifically in Morocco. Collective reconversion to drip irrigation is considered to be the main key to achieve these goals. The National Irrigation Water Saving Programme (PNEEI) aims the reconversion of 710 000 ha on the horizon of 2022. The collective conversion is one of the five components of PNEEI and aims the conversion of large scale hydraulic sectors. This work presents the process example of one area of collective conversion experience in the El Haouz perimeter, which is located in the south of Morocco and highly suffering from water shortage.

This paper will analyze the new experience of the project of the collective reconversion in Ouled Said Taourirt Skhirat area which is financed by the European Bank of Investment (EBI), it concerns 5453 hectares for 2700 farmers. The implementation cost of this project is 369 Million of Dirhams that cover the network equipment installation knowing that the farmer's network equipment is assuring within the framework of the Agricultural Development Fund (ADF).

It faces many challenges especially concerning the technical choices and the collective management of the water network and irrigations. This concerns particularly the adaptation of farmers to a new technique of irrigation, adaptation of managers of the collective water network to a new management and maintenance

system, payment of royalties and accompanying farmers. In order to guarantee these reconversion projects' sustainability, the procedures could be adapted to field realities primarily by integrating farmers and taking into account their expectations not only in terms of crop rotation but also in management modes.

The most important in such projects is the institutional organization of the beneficiary farmers as AUEA (Association of water users for irrigation), which plays a key role in the management and the farmers engagement in collaboration with Regional Office executives.

**Keywords:** water, scarcity, collective reconversion, economy and valorisation.

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## **Use of wind energy for desalination of seawater in the field of irrigation**

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**Abstract.** In the context of the scarcity of water resources and the population growth that the world is experiencing, the only resource still available in inexhaustible quantities is sea water. The exploitation of this resource is possible only through the use of desalination techniques.

The cost of energy was always the main constraint to water desalination, scientists forced themselves to develop new techniques to use renewable energies, in particular wind energy, to satisfy the high energy consumption of desalination plants.

Morocco enjoys a privileged geographical location. In fact, Morocco is surrounded by 3 seas: the Atlantic Ocean, the Mediterranean and the great sand sea of the Sahara. In terms of energy, Morocco has a large wind potential, especially in the South. In fact, according to the World Wind Energy Council, Morocco is the 3rd wind energy producer in Africa with a capacity of 120MW.

Within this framework an ambitious project is currently being prepared by the Ministry of Agriculture, Maritime Fisheries, Rural Development and Water and Forests of Morocco, the construction of a desalination plant for irrigation and a 40 MW wind farm in Dakhla, which will serve a new irrigated area in Dakhla of 5,000 ha. This desalination station and sea intake will be located 75 km north of Dakhla and will have a capacity of 100,000 m<sup>3</sup>/d, 30 million m<sup>3</sup>/year. It will use reverse osmosis technology to produce water that meets international standards for irrigation water quality.

This megaproject will have a significant economic impact on the Dakhla-Oued Eddahab region; first, the production of nearly 500,000 tonnes of market gardening for an added value of about 500 million DH per year. Second, the creation of nearly 10,000 permanent jobs and integration of young promoters in the project. And third is the contribution to the preservation and sustainability of the groundwater in the Dakhla aquifer. The project will require a global investment of 1700 Million dirhams split in two: 1300 million dirhams for the desalination plant and the wind farm and 400 million dirhams for the irrigation network.

In fact, the coastal zone of the Dakhla-Oued Eddahab region enjoys favourable conditions for the production of market gardening first because of its latitude and its climate, which allow a precocity of 2 to 3 weeks compared to the Souss-Massa region. This comparative advantage is now limited by the available water resources made up of the fossil groundwater resources of the Dakhla aquifer that is not renewable. The creation of wealth and the sustainable management of water resources in the region remain dependent on the development of new water resources, particularly through the desalination of sea water.

This project carried out by the Ministry of Agriculture of Morocco will be carried out as part of a public-private partnership for the co-financing, design, construction and management of the desalination and irrigation infrastructure of the project for a period of 22 years. It presents itself as a model for the good management of climate change through the use of renewable energies and the safeguarding of groundwater resources.

**Keywords:** wind energy, desalination, irrigation, PPP

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## **Desalination of seawater in Morocco: an integrated vision for the management of irrigation water in the context of climate change. Case study of Chtouka and Dakhla PPP projects**

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**Abstract:** Located between the southern Mediterranean and the great Sahara, Morocco has a semi-arid climate characterized by low and irregular rainfall and a succession of dry years. With demographic and economic growth, the country's water needs are constantly increasing. Desalination of seawater is an option adopted by the government to deal with the drying up of water resources. Several projects have been initiated to this effect in order to secure drinking water and irrigation needs.

In our study, we evaluate the contributions of the Public-Private Partnership (PPP) set-up from the institutional, financial, technical and management points of view, as well as the contribution of this set-up to the success of large desalination projects for irrigation. To achieve our objective, we focused on the study of the two desalination projects for irrigation of Chtouka and Dakhla, based on the evaluation of the different components of the two projects, and the key success factors of each of them in order to highlight the contributions of PPP for the success of these desalination projects.

Our study reveals that the PPP structure brings several advantages to the desalination projects for irrigation of Chtouka and Dakhla, including mainly: the participation of the private partner in the financing, the sharing of risks between the two public and private parties, the commitment of the private partner with its know-how and experience in the field, as well as the sustainable management of the various project components. The Dakhla project also presents a benefit compared to the other desalination PPP projects, which is manifested in the fact that it is the first project registered in the law N°86-12 relating to PPP contracts and that it is based on the coupling with renewable energies, more precisely wind energy.

At the same time, the PPP arrangement has risks in terms of control of delays caused by external events and flexibility in changing the term of existing contracts.

**Keywords:** Public-Private Partnership, desalination, irrigation, climate change, Chtouka, Dakhla

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## **Low-cost Technologies use in managing irrigation water management in the MENA: Study case of Nile Delta in Egypt**

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**Abstract :** Water scarcity is one of the most critical issues facing the agricultural sector in Egypt and the rest of MENA region. To increase the water use efficiency especially in agriculture, the largest user of water in the region, the adoption of new technologies is necessary. Similarly to most of the global south, cost is among of the bottlenecks in the face of the farmers access to new technologies. In this study, the “low-cost” technologies use in Egypt, specifically in the Nile delta, as a way to expand the use of technologies towards better irrigation water use in agriculture. After implementing a PRISMA-based systematic review, a total of 20 papers were obtained from Google Scholar and Springer using the keywords: "Egypt" AND "irrigation" AND "low cost" OR "low-cost" OR "cost-effective" OR "cost-effective". According to the results, many low-cost technologies and techniques are applied in delta farms, such as low-cost soil moisture sensors within smart monitoring units operated by Solar Photo Voltaic Cells (SPVC). To improve the quality of drainage water to reuse again in irrigation, low-cost solutions such as sand filters mixed with other filtration media improve the sand's performance in removing the suspended solids and organic matter from agricultural drain water. Low Concentrated Photovoltaic (LCPV) and integrated solar power systems for greenhouses irrigation systems were used for energy saving. Low-cost wastewater treatment technologies

have been investigated to reuse wastewater for irrigation by chemically enhanced primary treatment (CEPT) and Constructed wetlands. In this study, several development paths for increasing the adoption of low-cost technologies in irrigation water management in Egypt and the MENA.

**Keywords:** Low-cost technologies, irrigation management, Delta, sensors, solar energy

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## **Rice irrigated with treated urban wastewater – trial safety assessment in Portugal**

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**Abstract:** Improving practices of water saving in irrigation is a priority facing global climate changes. To cope with water scarcity, irrigation with treated wastewater (TWW) is becoming a solution, posing several health and environmental risks on agricultural fields. This preliminary study, sponsored by the MEDWATERICE project ([www.medwaterice.org](http://www.medwaterice.org)), aimed to assess the physicochemical impacts of rice irrigated with TWW applied with a subsurface drip irrigation (SDI) system, focusing on rice food, soil, and environmental safety. Normal water and flooding were used as a reference for comparison. The experimental scheme considered three treatments with five repetitions, namely the TWW irrigation with SDI, the normal water with SDI, and the flooded irrigation with normal water. The pots filled with 15 L of soil, sowed with a local traditional rice variety, were kept outdoors. The fertilization scheme followed the usual one under field conditions. The irrigation frequency varied from three to five times a week. Measurements of physicochemical properties of irrigation water, drainage and rice grain were carried out, according to the analytical reference methods. Results showed that the irrigation with TWW raises the salinity of drainage water, but that the rice grain does not present increased risks to public health due to the low content of arsenic, cadmium, lead and mercury. However, the irrigation method must be adapted to an SDI to avoid human and animal contact with putative contaminants present in this water and thus safeguarding Environmental and Food Safety. Long term soil effects of TWW, including winter percolation, should be assessed in the future.

# Challenges of rice drip irrigation: field assessment toward sustainability in Lis valley, Portugal

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**Abstract:** Increasing rice production through cultivation on land that is not suitable for flooding, namely on sloping fields or on light textured soils, reconciling the reduction in water consumption, is a major challenge necessary to respond to the increase in rice demand in the world market. There are experiences in several regions of the globe that prove that drip irrigation can be viable due to water saving, use of unconventional water resources, irrigation automation and ease of cultural rotation. In this sense, sponsored by the MEDWATERICE project ([www.medwaterice.org](http://www.medwaterice.org)), an innovative experimental work of rice drip irrigation, carried out in Vale do Lis, Portugal, on high land and light soil, outside the traditional paddies, to assess feasibility and identify the main constraints. This communication presents the study carried out in 2020 and 2021 with the objective to test the rice drip irrigation, with a planting density about 50 plants per m<sup>2</sup>. The irrigation system comprises drip lines of 16.2 mm diameter, dripper spacing of 0.30 m, with 1.0 L/h with pressure of 1.0 bar, usually with an irrigation event per day. The results obtained were characterized by great variability in the crop development, where the maximum production reached 7 t/ha and the water productivity 0.64 kg/m<sup>3</sup>, but with low average productions of the order of 2.5 - 4.2 t/ha, because of high unproductivity in the maturation phase. An important step in this study is to test varieties specially adapted to aerobic conditions and with a deeper root system, to favour water and nutritional comfort. There are open agronomic issues, such as weed control, irrigation, and fertilization management, concluding that more knowledge of the response of the crop to soil moisture in the reproductive phase is needed to optimize productivity and water and energy savings.

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## Hydraulic characteristics of SLECI and Moistube irrigation system as influenced by pressure operating, water quality and soil texture?

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**Abstract :** In Morocco and like most countries with a semi-arid climate, agriculture consumes more than 80% of fresh water resources. Consequently, irrigated agriculture is under pressure to increase crop water productivity. The use of sub-drip irrigation could save more water by minimizing unproductive water loss components such as surface runoff, soil evaporation and percolation. Clay element (*SLECI*) and *Moistube* are new technology recently developed for underground irrigation. In *Moistube* irrigation technic water emits from a semi-permeable membrane at a slow rate depending on the applied pressure and soil water potential. Regarding *SLECI* technology, water flow depends both on the density of clay pores (M, XL), operating pressure and the soil water potential itself linked to the soil texture. Both technologies are relatively new and at an experimental stage. Consequently, there is still little data on their hydraulic performance and the parameters that govern their operation. The aim of this study was to determine in the laboratory the flow characteristics as a function of pressure, the effect of suspended and dissolved solids and soil texture on the emission characteristics. The pressure-discharge relationship was determined within a range of 0.2 bar and 1 bar. The risk of clogging was evaluated using water containing algae, low and high concentrations of suspended and dissolved solids at 0.2 bar and 0.4 bar. For both irrigation technologies, the results indicated that the discharge follows a power function with the applied pressure. The exponent values of the fitted power function equations were greater than 1 (1.432 in average), showing a laminar flow regime and high sensitivity to pressure variation. The coefficient of variation was within the acceptable range (<10%) and decreases with increasing operating pressure. The infiltration rate decreased when the *Moistube* and *SLECI* elements were buried compared to unburied states. The discharge decreased linearly over time because of clogging. Suspended solids mainly algae had a more severe clogging effect than dissolved solids. The results of this study should help in the design, operation and maintenance of sub drip irrigation systems.

**Keywords:** Sub-drip irrigation, low-pressure, micro-irrigation, *Moistube*, *SLECI*, water quality, pressure operating

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## Effects of Water Scarcity using two Irrigation Strategies on Physiology and Productivity of Eggplants Crops Grown under Mediterranean Climate Conditions of Morocco

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**Abstract:** Morocco is one of the African countries who was affected by irregular and declining rainfall during the past decade. The focus of scientific research on water management is needed in order to reduce the negative impact of drought on plant production. Chlorophyll fluorescence is a non-destructive measurement to study the balance between metabolic and energy processes that can be affected by rising temperatures and drought. This process gives useful information about physiological stress, following the interruption of the electron transfer chain which is due to the process of photoinhibition. Trials were conducted in the “ARID” area, Nador, Morocco using two irrigation strategies: One adapted by the grower (10cm between drippers or 100% irrigation) and the water stress treatment (20cm between drippers or 50% irrigation). Thirteen eggplant genotypes selected for their drought tolerance and two local commercial varieties of eggplants were tested under each type of irrigation. The planting density was 10 000 plants per ha. The planting date was August 21, 2021. The trial ended on January 10, 2021. Growth and yield measurements were taken during these trials. In addition, physiological measurements such as relative water content (RWC) and chlorophyll fluorescence were taken. Sixty chlorophyll fluorescence parameters ( $F_0$ ,  $F_v$ ,  $F_m$ , ABS, ET, TR, DI,  $V_i$ ,  $V_j$ , PI, etc.) were measured during typical sunny days. The results showed different responses of genotypes and varieties to water stress treatments in terms of growth and yield. Indicators of physiological stress revealed different responses of genotypes for treatments.

**Keywords:** breeding, chlorophyll a fluorescence, dripper, drought, photosynthesis, stress index, tolerance and yield.

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## Effects of Water Saving on Stomatal Conductance, Electron Transfer Chain of the Light Reactions of Photosynthesis, Growth and Yield of Table Grapes Grown Northeast of Morocco

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**Abstract:** Water has become a limiting factor for Moroccan agriculture over the past decade. The water shortage has disrupted the production balance of farmers and especially among table grape growers in the Mediterranean area of northeastern Morocco. Despite the investment of growers in such a production system, these farmers are at risk of losing their production due to the lack of surface water reserves and the high salinity of groundwater. Experiments were carried out at a table grape (*Vitis vinefera* var. Regal) production who owns about twenty hectares located in the “Bouarg” plain, Nador. Two treatments were applied during these experiments: the control treatment has a dripper with a flow rate of 4L/H and which represents 100% of irrigation (or irrigation adapted by the grower) while the second treatment has a dripper of 3L/H and which represents 25% of water saving. Split plot design was adapted in this trial. A digital station was installed and the probes were placed at a water depth of 10cm below some drippers of each treatment. These probes of soil moisture and air temperature and relative humidity were connected to a digital station which transmits measurements. The data acquisition platform was installed in smartphones to consult and download these measurements online. Moreover, the transfer situation of electrons at the transport chain during the light reactions of photosynthesis was quantified using HPEA-Hansatech. This quantification of this situation of electron transfer generates sixty physiological stress indices for the crops. In addition stomatal conductance and plant growth parameters and fruit yield were measured. The results obtained will be discussed and reported.

**Keywords:** drought, irrigation, photosystem, microclimate, sensors, stress, *Vitis vinefera*, water flow.

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## L'effet de l'azote, apporté par fertigation, sur la productivité de la betterave irriguée par micro-irrigation installée dans un climat semi-aride TADLA

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**Résumé :** L'efficacité de l'utilisation des terres agricoles constitue un objectif primordial de l'agriculture marocaine. Dans le cadre d'un développement durable des ressources naturelles (Eau) et de

l'optimisation de l'utilisation des engrais azotés, cette étude a évalué les effets que peuvent avoir la limitation hydrique et azotée sur la production finale en racines et la teneur en sucre de la betterave à sucre dans une région semi-aride de la plaine de Tadla. L'essai a été réalisé selon un protocole en split plot. L'étude a porté sur quatre régimes hydriques à savoir : (T1) irrigué à 100 % des besoins en eau de la betterave à sucre, (T2) irrigué à 80 % des besoins en eau de la culture, (T3) irrigué à 60 % des besoins en eau de la culture et (T4) irrigué à 40 % des besoins en eau de cette culture. Quatre niveaux de fertilisation azotée ont été appliqués par combinaison : D1 (80 unités/ha), D2 (120 unités/ha), D3 (240 unités/ha) et D4 (320 unités/ha). Le rendement racine, le développement foliaire, le sucre brut, et la teneur d'azote minéral dans le sol ont été mesurés et discutés. Il apparaît que la réduction de la surface foliaire est étroitement liée au déficit hydrique et au niveau de la fertilisation azotée. L'essai montre que le stress dû à la contrainte hydrique a induit chez la betterave à sucre, une baisse du rendement racinaire. Pendant que la teneur en sucre a légèrement augmenté au niveau des régimes hydriques stressés. L'expérimentation a montré aussi que le stress hydrique réduit l'absorption d'azote par la plante. L'efficacité d'utilisation de l'azote semble être plus influencée par le régime hydrique que par le niveau de la fertilisation azotée. Mots clés : Betterave à sucre, fertilisation azotée, stress hydrique, rendement racine, qualité technologique, fertigation.

**Mots clés :** *Aléa inondation, degré d'exposition, Zaio, Cartographie*

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## **NUMERICAL SIMULATION OF CLOGGING OF TWO TYPES OF EMITTERS WITH SIMILAR PROPERTIES**

### **SIMULATION NUMÉRIQUE DU COLMATAGE DE DEUX TYPES DE GOUTTEURS À PROPRIÉTÉS SIMILAIRES**

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**Abstract:** The benefits of drip irrigation are numerous, including water savings, control of nutritional and phytosanitary crop planning and finally energy efficiency of irrigation. In these systems, the emitter is the most vulnerable component to clogging, which in critical states can cause a reduction in performance and shorten the life of the distribution system. In the absence of adequate filtration and when the flow is through the narrow labyrinth channel of the emitter, clogging can be created by continuous deposition of solid particles, organic matter, dissolved salts, chemical precipitates, bacteria and other impurities. It is obvious that it is impossible to physically visualise the hydraulic behaviour of the charged water in the labyrinths. However, due to the increasing performance of computational tools and simulation software, it is possible to simulate this flow through Computational Fluid Dynamics (CFD), which has become one of the main techniques for describing the flow and deposition of the solid phase inside the emitter.

This study aims to numerically simulate the behaviour and the flow of the fluid inside two emitters, widely used in the industry, with different types but approximately identical flow rates. The fluid takes in its flow an inert solid suspension of fixed concentration. One of the emitters is compensating-pressure and the other is non-compensating-pressure and the numerical simulation model used is the RNG  $\kappa$ - $\epsilon$  two-phase model. The results found showed that the regions affected by clogging are mainly the corners of the labyrinth channel and the recirculation vortex zones. The trajectory field plot reveals that as the clogging increases the serpentine fluid threads become thinner

**Keywords:** Drip irrigation, Emitter, Labyrinth, Clogging, Computational Fluid Dynamics.

## **EXPERIMENTAL STUDY OF CLOGGING OF THREE DIFFERENT TYPES OF EMITTERS WITH SIMILAR PROPERTIES**

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**Abstract:** The drip irrigation process has been designed to reduce water losses, to split up water supplies and to combine it, to a large extent, with the injection of fertilizers. However, in drip irrigation systems, the clogging of emitters is a major problem that significantly reduces the performance of drip irrigation systems. The water used in these systems is generally loaded with suspensions which cause, as

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a result, the clogging of the emitters. This work was carried out in order to evaluate the clogging rate in three different types of emitters with roughly similar flow rates, tested in an experimental drip irrigation system, using water pumped from the Sebou River. Thus, we tested a compensating-pressure emitter, named E1 and a two non-compensating-pressure emitter named E2 and E3. Each treatment was the subject of 112 times of irrigation which lasted 397 hours spread over a period of two months. To evaluate the hydraulic performance of the emitters, we used the following three coefficients measuring the effect of clogging: (i) The variation of the flow ratio (Dra), (ii) The emission uniformity coefficient (EU) and (iii) The Christiansen uniformity coefficient (CU). We observed, during the experiment, that there was no completely clogged emitter. However, as the clogging rate increased, the average flow rates measured in some emitters decreased by 89% compared to the initial flow rates at the end of the test. We observed, during the experiment, flow fluctuations during the evolution of the clogging, which could come from a partial recovery of flow.

**Keywords:** Drip irrigation, Clogging, Pressure-compensating emitter, Non-pressure-compensating emitters.

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## **EFFECT OF TREATED WASTEWATER IRRIGATION ON ORNAMENTAL PLANTS DEVELOPMENT UNDER SURFACE AND SUBSURFACE DRIP IRRIGATION CASE STUDY OF LANTANA AND HIBISCUS, MOROCCO.**

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**Abstract.** In areas suffering from water stress, such as Morocco, the use of treated wastewater represents a strategic perspective for sustainable agricultural development. However, technological and management innovations are needed to make it feasible and effective. The main objective of this work is to evaluate the effect of irrigation with treated wastewater compared to fresh water on the growth of two ornamental plants: Rosa Sinensis hibiscus and Lantana Camara. It also aims to examine the impact of treated wastewater on the hydraulic performance of different irrigation systems. To carry out this study, irrigation was applied by using two irrigation systems: the subsurface drip irrigation and the surface drip irrigation. Also, two sources of water were compared: treated wastewater from the WWTP of M'zar (tertiary treatment) and well water Durant 2 months. The results obtained showed that the treated wastewater generally promoted a better development of agronomic parameters such as height, number of branches, leaves, and flowers for both crops. The same observation was also made regarding the esthetical parameter. For the irrigation system factor, the results obtained showed a better development under the subsurface drip irrigation system; thus, the combination of treated wastewater and subsurface drip irrigation provided the best results for both crops. Regarding the hydraulic performance of the irrigation system, no risk of clogging of the distributors was observed in relation to the water nature; the uniformity coefficient and distribution uniformity remained above 90%.

**Keywords:** Treated wastewater, Hibiscus, Lantana, Drip Irrigation, Subsurface drip Irrigation, Hydraulic

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## **Enhancing dam management performance under deficit irrigation. Study case: Ziz watershed**

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**Abstract:** The present study was carried out on the Ziz watershed in the southeastern part of Morocco. The objective was to assess the likelihood of enhancing dam performance using deficit irrigation. The study attempted to understand the runoff patterns in the Ziz watershed. Temporal trend analysis of the daily runoff over the period ranged from 1982 to 2012 was conducted using Mann–Kendall (MK) and Sen Slope Tests, coded on Python script showing a decreasing trend over the coming years. Second, the Hassan Addakhil dam performance was assessed over the period ranged from 1982 to 2012 under two scenarios: 100% (T1) of the irrigation water requirement and at 60–100–80% (T2) of the irrigation water requirement to adapt to the future trend of inflows. The reliability, resilience, and vulnerability were considered as the dam performance indicators. The results show that under the T2 scenario, the dam reliability and resilience have increased respectively from 61% to 71% and from 25% to 33%, while vulnerability decreased slightly by one point from 7 to 6.

**Keywords:** Ziz watershed, Runoff trend analysis, Dam management, Deficit irrigation

## Using Digital Technology Based on Soil Moisture Sensors for Saving Irrigation Water for the Moroccan Horticultural Production Farms

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**Abstract:** Water has become a limiting factor for Moroccan agriculture over the past decade. To remedy this problem, several alternatives have been adopted to deal with this water scarcity which has disrupted the agricultural sector. The technology of digital sensors installed in the soil seems to be an effective solution to instantly measure the soil moisture content near the roots and then predict the irrigation flow required for production. The "ARVUM" technology has methods for reading soil humidity levels, by sensors, which are connected to a weather station installed at farm level and connected to a digital platform (Apps or a website), which allows to read, download and save data. This station contains several chains that can be linked to other sensors according to the needs and interest of the grower; such as sensors for temperature, humidity (air, leaf, and soil), light, water flow, conductivity, etc. These stations are also equipped with solar panels and batteries that provide energy autonomy for the operation of this system. This technology has telecommunications SIM cards that allow the transfer of data in a digital platform and which will be consulted online by the growers. Many platforms have been installed in several areas of Morocco, for different crops such as citrus, table grapes, as well as for small fruit production including strawberries and blueberries. Trial results showed significant savings in terms of the amount of irrigation water adopting this technology. More details about the obtained results in each platform will be presented.

**Keywords:** drought, field capacity, heat stress, horticulture, precision agriculture, root, sensors, soil humidity.

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