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PROCEEDINGS

Volume 64, book 1.2.
Agricultural Machinery and Technologies, Agrarian Science and Veterinary Medicine & Maintenance and Reliability & Thermal, Hydro-and Pneumatic Equipment & Ecology and Conservation &Industrial Design

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Земеделска техника и технологии, аграрни науки и ветеринарна медицина & Ремонт и надеждност & Топлотехника, хидравлика и пневматика & Екология и опазване на околната среда & Промишлен дизайн

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The papers have been reviewed.

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Agricultural Machinery and Technologies, Agrarian Science and Veterinary Medicine & Maintenance and Reliability & Thermal, Hydro- and Pneumatic Equipment & Ecology and Conservation & Industrial Design

Content

THU-SSS-AMT&ASVM-01

INTEGRATED PEST AND DISEASE MANAGEMENT IN RAPESEED (CANOLA) CULTIVATION

Durim Verrija – Student
Technical University of Moldova
168 Ștefan cel Mare Blvd.,
Chișinău, Moldova, MD-2004

Petya Angelova, PhD
Department Agriculture machinery,
University of Ruse "Angel Kanchev"
Tel.: +359 082 888 288
E-mail: pangelova@uni-ruse.bg

Abstract: *Integrated Pest and Disease Management in rapeseed (canola) is a balanced approach that combines three types of methods. Agronomic practices (such as crop rotation and resistant varieties) create an unfavourable environment for the development of problems. Biological methods encourage the natural enemies of pests, while chemical controls are used precisely and only when necessary to preserve their efficacy and minimize environmental impact. The goal of this comprehensive approach is sustainable and economically viable production.*

Keywords: *canola, pest, disease.*

INTRODUCTION

Brassica napus L., commonly known as rapeseed or canola, is a globally significant oilseed crop, prized for its high-quality vegetable oil and protein-rich meal. Its cultivation, however, is consistently challenged by a diverse array of fungal pathogens, insect pests, and viral diseases that can cause substantial yield losses and economic damage. Conventional crop protection has historically relied heavily on the prophylactic application of synthetic pesticides. While often effective in the short term, this approach has led to unintended consequences, including the development of pesticide resistance in pest populations, the disruption of beneficial arthropod and microbial communities, and growing environmental and food safety concerns.

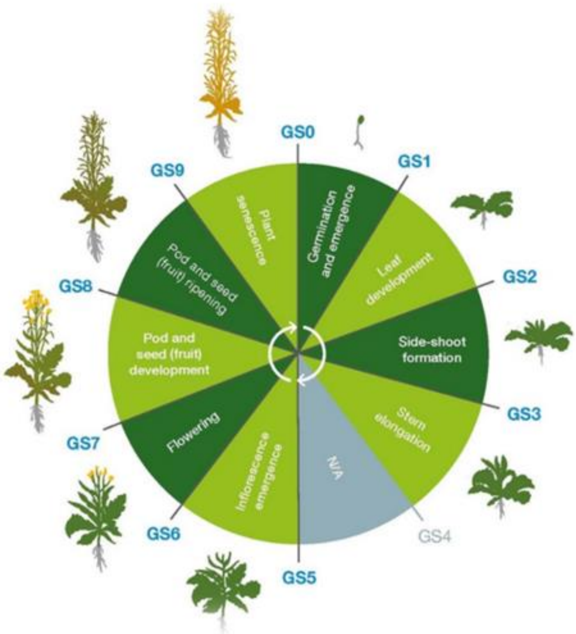

Fig 1. Main Growth Stages of Winter and spring rapeseed

In response to these challenges, Integrated Pest and Disease Management (IPDM) has emerged as the cornerstone of sustainable canola production. IPDM is not a single tactic, but a holistic, knowledge-based strategy that synergistically combines multiple control measures. This approach aims to maintain pest and disease populations below economically damaging thresholds while minimizing harmful effects on human health and agroecosystems. The core pillars of IPDM are agronomic (cultural) practices, biological control, and the judicious use of chemical pesticides.

This report will provide a comprehensive overview of the modern IPDM framework for rapeseed cultivation. It will detail the specific agronomic strategies designed to suppress pest pressures, explore the role of biological control agents, and outline the principles for the rational and targeted use of chemical interventions. By integrating these methods, producers can enhance crop resilience, ensure long-term productivity, and align with the principles of agricultural sustainability

EXPOSURE

The cultivation of rapeseed (Brassica napus L.), particularly its canola variant, is a cornerstone of global oilseed production. However, its agronomic success is perpetually challenged by a complex of fungal pathogens, insect pests, and viral diseases that threaten yield stability and economic viability. For decades, reliance on synthetic pesticides served as the primary line of defense. While effective in the short term, this approach has unveiled significant drawbacks, including the accelerated evolution of resistant pest strains, the detrimental disruption of beneficial ecosystems, and mounting environmental concerns. In response to these challenges, Integrated Pest and Disease Management (IPDM) has emerged as the paradigm of modern, sustainable agriculture. IPDM is a dynamic and knowledge-intensive strategy that moves beyond singular solutions, instead advocating for a synergistic integration of agronomic, biological, and chemical methods. The overarching goal is not the eradication of pests and diseases, but rather their sustainable management below economically damaging thresholds, thereby ensuring long-term crop productivity, environmental health, and farm profitability.

The foundation of any successful IPDM program in rapeseed is built upon robust agronomic, or cultural, practices. These methods are primarily preventative, designed to create an environment inherently suppressive to pests and diseases while promoting crop vigor. The most critical of these practices is extended crop rotation. By rotating canola with non-host crops such as cereals or legumes for a minimum of three to four years, the life cycles of host-specific pathogens like Plenodomus lingam, the causal agent of Blackleg, and Sclerotinia sclerotiorum, responsible for Sclerotinia stem rot, are effectively broken. This practice drastically reduces the inoculum potential present in soil and infected crop residues. Complementing rotation is the strategic deployment of genetically resistant varieties. Plant breeding has developed cultivars with both qualitative resistance, based on single major genes, and more durable quantitative resistance, which is polygenic and partial. The use of such varieties, especially when combined with other practices, provides a highly effective and low-input form of control. Furthermore, meticulous attention to sowing practices—such as optimizing sowing date to avoid pest peaks, ensuring shallow sowing in optimal soil conditions for rapid emergence, and using high-quality seeds - establishes a uniform and competitive crop stand that is more resilient to initial pressures.

Building upon this agronomic foundation, biological control methods introduce a layer of natural regulation into the cropping system. This pillar of IPDM involves the conservation and augmentation of living organisms to suppress harmful populations. A key aspect is the preservation of naturally occurring beneficial arthropods, such as predatory ground beetles and parasitoid wasps, which act as natural enemies to common pests like the cabbage stem flea beetle and pollen beetle. Conservation is achieved by minimizing the impact of broad-spectrum insecticides and by enhancing biodiversity on farm margins, for instance through the establishment of flowering strips that provide nectar and habitat. Beyond macrobials, microbial biocontrol agents offer targeted solutions. Commercially available formulations of beneficial fungi like Trichoderma spp. or bacteria like Bacillus subtilis can be applied as seed treatments or soil amendments to protect against damping-off and soil-borne diseases through competition and antibiosis. Additionally, the practice of biofumigation, which involves growing and incorporating specific mustard species that release natural biocidal compounds (glucosinolates) into the soil, provides a potent tool for reducing the load of soil-borne pathogens and weeds.

Within the IPDM framework, chemical methods are not abandoned but are instead employed as a precision tool of last resort, guided by the principles of necessity and selectivity. The prophylactic and calendar-based spraying is replaced by a decision-making process rooted in continuous monitoring. The application of insecticides and fungicides is triggered only when scouting data and established economic thresholds indicate that the cost of damage by the pest or disease will exceed the cost of control. This threshold-based approach prevents unnecessary applications, thereby conserving beneficial insect populations and delaying the development of resistance. Furthermore, the strategic use of insecticide- and fungicide-treated seeds exemplifies a targeted chemical intervention, protecting the vulnerable seedling stage with a minimal environmental footprint. When in-season chemical applications are unavoidable, strict anti-resistance strategies are paramount. These include the conscientious rotation of active ingredients from different mode of action (MoA) groups and the use of pre-approved mixture partners to mitigate the selection pressure on pest and pathogen populations, thereby preserving the efficacy of existing chemistries for the future.

During the growing season, rapeseed is attacked by diverse groups of pests. Flea beetles (Phyllotreta spp.) cause characteristic holes in leaves, reducing photosynthetic activity. Pollen beetles (Brassicogethes aeneus) damage flowers and negatively affect pollination and pod formation. The cabbage aphid (Brevicoryne brassicae) weakens plants by sucking plant sap and transmitting viral infections. Cutworms (Agrotis segetum) and diamondback moths (Plutella xylostella) damage stems, leaves, and pods, with their larvae posing particular danger. The hairy rose chafer (Tropinota hirta) acts during sunny days during flowering, damaging petals and stamens.

Significant economic losses are also caused by disease pathogens. Phoma stem canker (Leptosphaeria maculans) appears in early development stages and leads to stem base infection and plant lodging. Alternaria leaf spot (Alternaria brassicae) causes dark spots on leaves and pods, which deteriorates seed quality. White mold (Sclerotinia sclerotiorum) and gray mold (Botrytis cinerea) develop under high humidity conditions and damage stems, flowers, and pods. Powdery mildew (Erysiphe cruciferarum) forms a characteristic white coating on leaves and reduces photosynthesis intensity.

The application of integrated protection systems involves combining agronomic, biological, and chemical methods. Among agronomic practices, the most important are crop rotation, selection of resistant varieties, and adherence to optimal sowing dates and rates. Biological control includes using natural enemies such as parasitic wasps (Braconidae) and predatory beetles (Carabidae), as well as applying microbial preparations based on Bacillus thuringiensis and Trichoderma spp.

Chemical protection is applied targetedly and when necessary, following integrated management principles. Fungicides such as Folicur and Amistar are used against main rapeseed diseases, with treatment timing strictly linked to crop phenological phases. Insecticides like Sherpa and Fastac are applied when economic thresholds are reached, considering their impact on beneficial entomofauna. The growth regulator Moddus reduces lodging risk and improves plant stability.


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Fig 2. The major insect pests of canola: 1) Phyllotreta atra L.; 2) M.aeneus; 3 и 4) A dense colony of cabbage aphid on the inflorescence apex; 5) Entomoscelis adonidis 6) T. hirta

Fig. 3.Rapeseed Diseases: Phoma and Alternaria

Effective rapeseed protection requires balanced application of all these methods, considering specific farm conditions and the dynamics of pest and disease development. The comprehensive approach ensures achievement of high and stable yields while maintaining ecological balance in agroecosystems.

In conclusion, Integrated Pest and Disease Management in rapeseed cultivation represents a sophisticated and holistic philosophy. Its efficacy is derived not from the isolated application of any single tactic, but from the strategic synergy between its core components.

Agronomic practices establish a resilient and suppressive foundation, biological control introduces self-regulating stability, and chemical interventions provide a calibrated, emergency response. By embracing this integrated approach, producers can navigate the challenges of rapeseed cultivation towards a future that is not only productive and profitable but also environmentally sound and sustainable.

CONCLUSION

The successful cultivation of rapeseed requires an integrated approach to pest and disease management that combines agronomic, biological, and chemical methods in a balanced system.

The main pests - flea beetles, pollen beetles, cabbage aphids, cutworms, and diamondback moths - cause significant damage to different plant organs during various growth stages, requiring timely monitoring and intervention.

Diseases such as Phoma stem canker, Alternaria leaf spot, white and gray mold, and powdery mildew can lead to substantial yield losses and quality deterioration, especially under favorable weather conditions.

Agronomic practices, particularly crop rotation and selection of resistant varieties, form the foundation of protection by creating unfavorable conditions for pest and pathogen development.

Biological control methods using natural enemies and microbial preparations provide an environmentally friendly alternative that helps maintain ecological balance in agrocenoses.

Chemical treatments should be applied judiciously, based on economic thresholds and with strict adherence to application timing, while implementing anti-resistance strategies.

The integration of all protection methods, adapted to specific growing conditions and pest dynamics, ensures sustainable rapeseed production with high economic indicators while minimizing environmental impact.

Continuous monitoring and implementation of modern scientific developments remain crucial elements for effective rapeseed protection and yield optimization..

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THU-SSS-AMT&ASVM-02

KEY PESTS AND DISEASES OF STRAWBERRIES AND THEIR MANAGEMENT

Natalia Cortes Silverio – Student
University of Huelva, Spain
Ingeniería agricola (agricultural engenieering)

Angel Ivanov, Asst. Prof.
Department Agriculture machinery,
University of Ruse "Angel Kanchev"
Tel.: +359 7174014
E-mail: aivanov@uni-ruse.bg

Abstract: *The strawberry (Fragaria × ananassa) is one of the most popular and economically important crops in the world. It is highly susceptible to various diseases and pests that can cause significant damage. To ensure high yield and fruit quality, it is essential to correctly identify problems and implement appropriate management methods. Spain is a leading producer of strawberries in Europe, with the province of Huelva (Andalusia) producing 97% of the strawberries for the domestic market and 30% for the global market. Despite the crop's economic importance, strawberry plantations are exposed to a number of pests and diseases that can reduce yields and fruit quality. This report presents a review of the main diseases and pests affecting strawberry crops, with particular emphasis on modern integrated management approaches. The study critically evaluates the effectiveness of various control strategies, including cultural, biological, biotechnical, and chemical methods, as well as their optimal integration into practice.*

By systematizing the most current scientific data and practical achievements in the field, this report aims to serve as a valuable source of information for researchers, practicing agronomists, plant protection product manufacturers, and governing bodies involved in the development of agricultural policy.

Keywords: *strawberry, pest, disease.*

INTRODUCTION

The province of Huelva, located in the southwestern part of Andalusia, has become a global leader in strawberry production, having established itself over recent decades as one of the most competitive regions in the world in this sector. The region accounts for over 90% of Spain's national strawberry production and a significant share of the European market, with supplies from Huelva dominating the supermarkets of Central and Northern Europe during the winter and spring months.

The success of the sector is due to favourable natural conditions, the implementation of modern technology, and the extensive experience accumulated since the late 19th century when the crop was first introduced to the region. This unique synergistic effect is supported by a comprehensive production chain, encompassing research institutions, efficient logistics, and a specialized workforce.

Huelva's Mediterranean climate, characterized by mild winters and warm summers, provides ideal conditions for strawberry cultivation. - The region's average temperature ranges from 10°C in winter to 25°C in summer, allowing for multiple harvests per year. The soil in Huelva is primarily acidic, with a pH range of 5.5-6.5, which is well-suited for strawberry growth. The soil's high organic matter content and good drainage also contribute to the region's success in strawberry production. Strawberry cultivation in Huelva typically begins in September, with the planting of new crops.

Farmers use a variety of cultivation techniques, including: mulching to retain moisture and suppress weeds; drip irrigation to optimize water use; integrated pest management (IPM) to minimize chemical use; harvesting takes place from January to May, with the peak season occurring in March and April; most strawberries are hand-picked to ensure quality and minimize damage. This report aims to conduct an in-depth analysis of the multidisciplinary factors behind the exceptional productivity and competitive advantage of the strawberry sector in Huelva. It will examine both the physical-geographical determinants - climate, soils, and hydrology - as well as the technological innovations, socio-economic dimensions, and institutional framework that together form one of the most successful models in modern European agriculture.

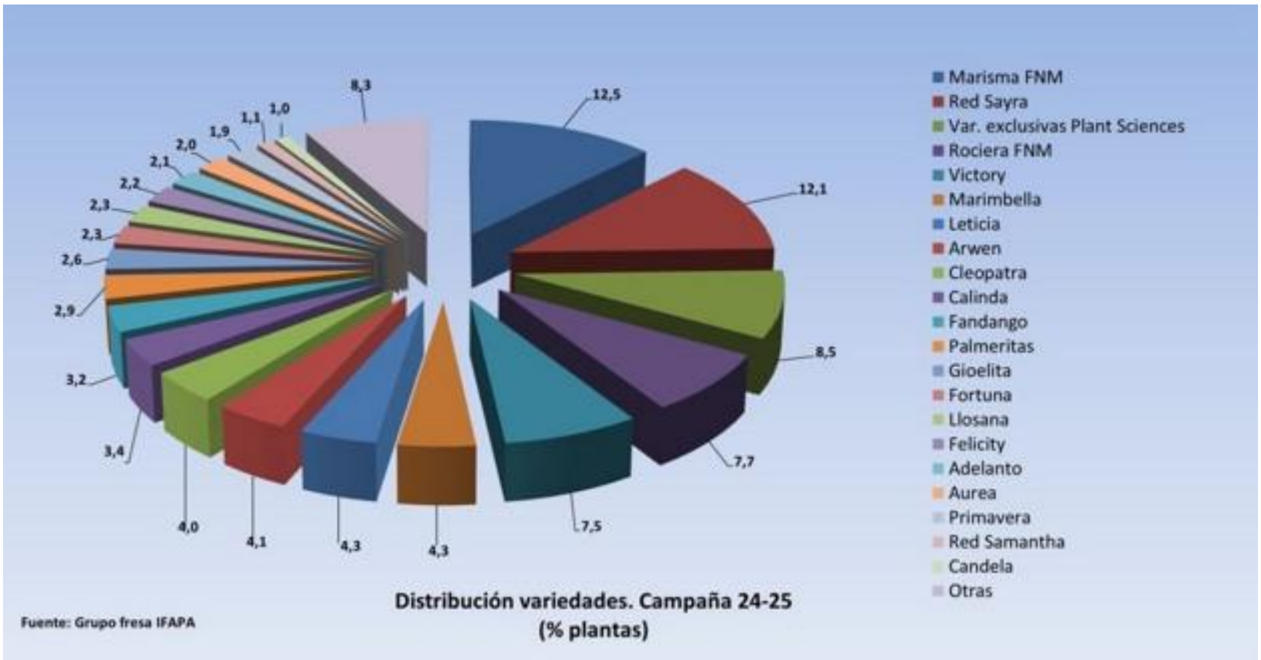

Fig 1. Varieties of strawberries that exist in Huelva(March 2025)

EXPOSURE

Strawberries are a crop that is frequently attacked by various diseases and pests, which can seriously affect both the quantity and quality of the harvest. Due to their high susceptibility to a wide range of diseases, both bacterial and fungal - with the latter causing the most significant damage - successful cultivation requires recognizing the main threats and implementing appropriate management measures.

The disease Anthracnose is caused by Colletotrichum acutatum, a phytopathogen of fungal origin. High air humidity and warm temperatures above 21°C favor the development of the disease, with the optimum temperature being between 26 and 28°C. Spots appear on the leaves at the edges and tips, with a variable shape, developing from the edges inward, with a dark brown color and a dry appearance. Initially, small round spots with a gray or black color may appear. Round and concave spots are noticeable on the fruits. At the beginning of the infection, the spots are light brown if the humidity is high. Over the days, the spots darken until they turn black. Usually the pathogen attacks ripe fruits, but if conditions are favorable, it also affects unripe fruits.

To prevent the spread, healthy plants are planted. Weeds that are hosts to the disease are also controlled. In the presence of plants affected by the pathogen, the affected plant organs must be removed, if the degree of infection is very serious, the entire plant must be removed. These measures significantly reduce the spread of the disease, but it is good to apply others related to crop rotation with others resistant to these pathogens.

Fungal diseases are the most common and dangerous for strawberries (Fig.2.). Gray Mold (Botrytis cinerea) is particularly harmful, as it attacks the fruits, covering them with a characteristic gray mold. The disease develops rapidly under humid conditions and can destroy a large part of the crop. To prevent it, it is important to maintain good ventilation between plants, avoid overwatering, and quickly remove infected fruits. When symptoms appear, treatment with suitable fungicides is recommended.

One of the most common and dangerous diseases in strawberries is gray mold (Botrytis cinerea), caused by the fungal pathogen Botrytis cinerea. The disease can attack leaves, flowers, and the fruits themselves. When infected, the fruits are typically covered with a web of grayish spores, after which they begin to decay and develop an unpleasant odor.

Humid conditions and poor air circulation in the bed are main factors that favor the spread of gray mold. Control measures include optimal plant spacing to ensure good air flow, regular removal of damaged fruits, and, if necessary, treatment with fungicides approved for garden use.

Phytophthora cactorum (Root Rot): A fungal disease-causing damage to roots and vascular system. Phytophthora is caused by a soil-borne fungus that attacks the crown and roots of strawberry plants. Symptoms include dark brown lesions on the crown and lower part of the stem, as well as yellowing and wilting of the leaves. Prevention measures include planting in well-drained soil and avoiding excessive watering. Fungicides can also be used to treat the disease.

Powdery mildew (Podosphaera aphanis) is another common disease in strawberries, also provoked by a fungal pathogen. The first sign is the appearance of a fine white coating on the leaf surface, which can gradually cover the flower stalks as well. Over time, the leaves curl, wilt, and the plant weakens significantly. Prevention against powdery mildew includes good soil drainage, moderate watering, and reducing excessive moisture. It is recommended to avoid planting strawberries too close together, and in case of severe infection, the use of specialized products may be necessary.

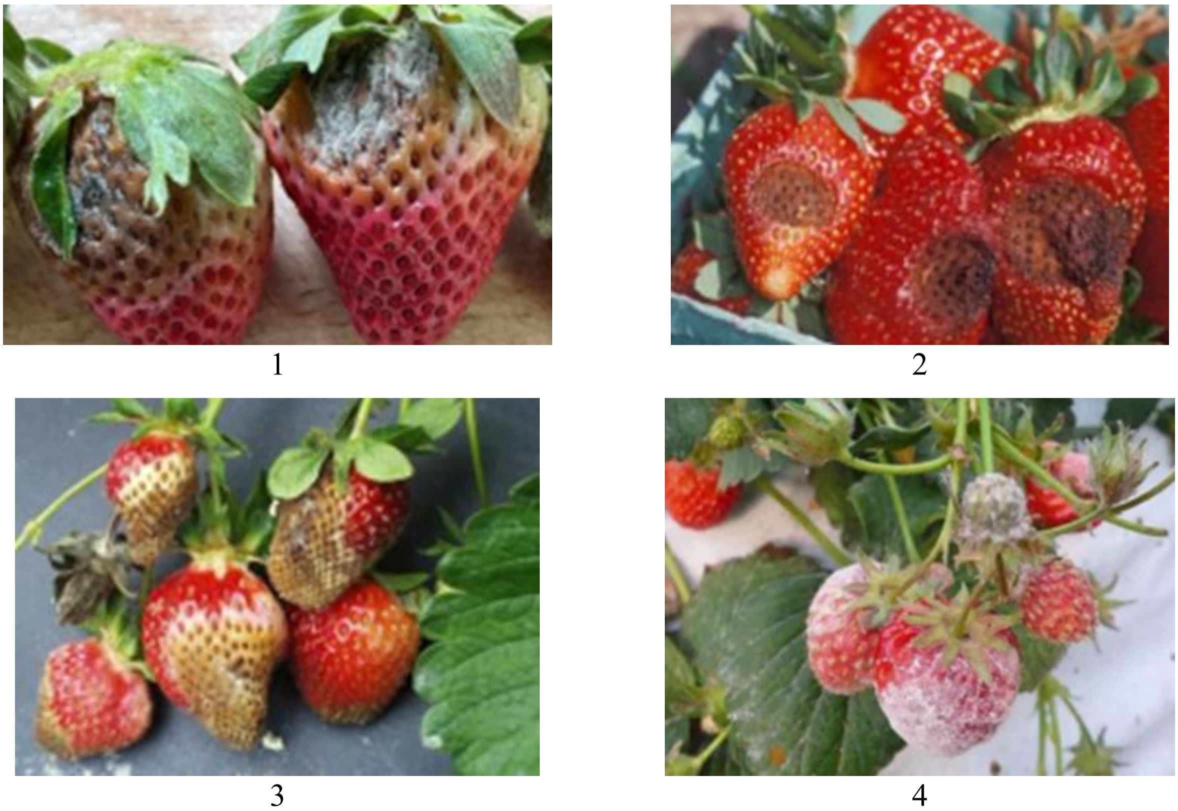

Fig. 2. Diseases in strawberries: 1) Botrytis cinerea (Gray Mold; 2) Colletotrichum acutatum (Anthracnose); 3) Phytophthora cactorum (Root Rot); 4) Powdery mildew

Strawberry pests are also diverse and can cause significant damage. Strawberry mites (Tetranychus urticae) are one of the most common, causing yellowing and wilting of the leaves. They develop rapidly in dry and warm conditions. Acaricides are used to control their population, as well as biological methods with predatory mites.

Aphids (Aphis spp.) are another important problem, as they not only suck plant juices, but also transmit viruses. They can be controlled with insecticides, but biological solutions, such as natural enemies (e.g. ladybugs), are increasingly preferred.

Two-spotted spider mites do the most damage in hot, dry weather, which happens to coincide with peak strawberry season. These mites will weaken the plants to the point where the greenery is more vulnerable to adverse weather and hungry pests, and will likely not survive the following winter. The mites primarily feed on leaves, especially on the undersides where they like to hide.

They pierce the leaves with their sharp mouthparts, drinking the sap within the leaves and causing the leaves to become stippled. This may not seem like a big deal in the grand scheme of strawberries, but it gets worse when the number of aphids multiply drastically throughout the year.

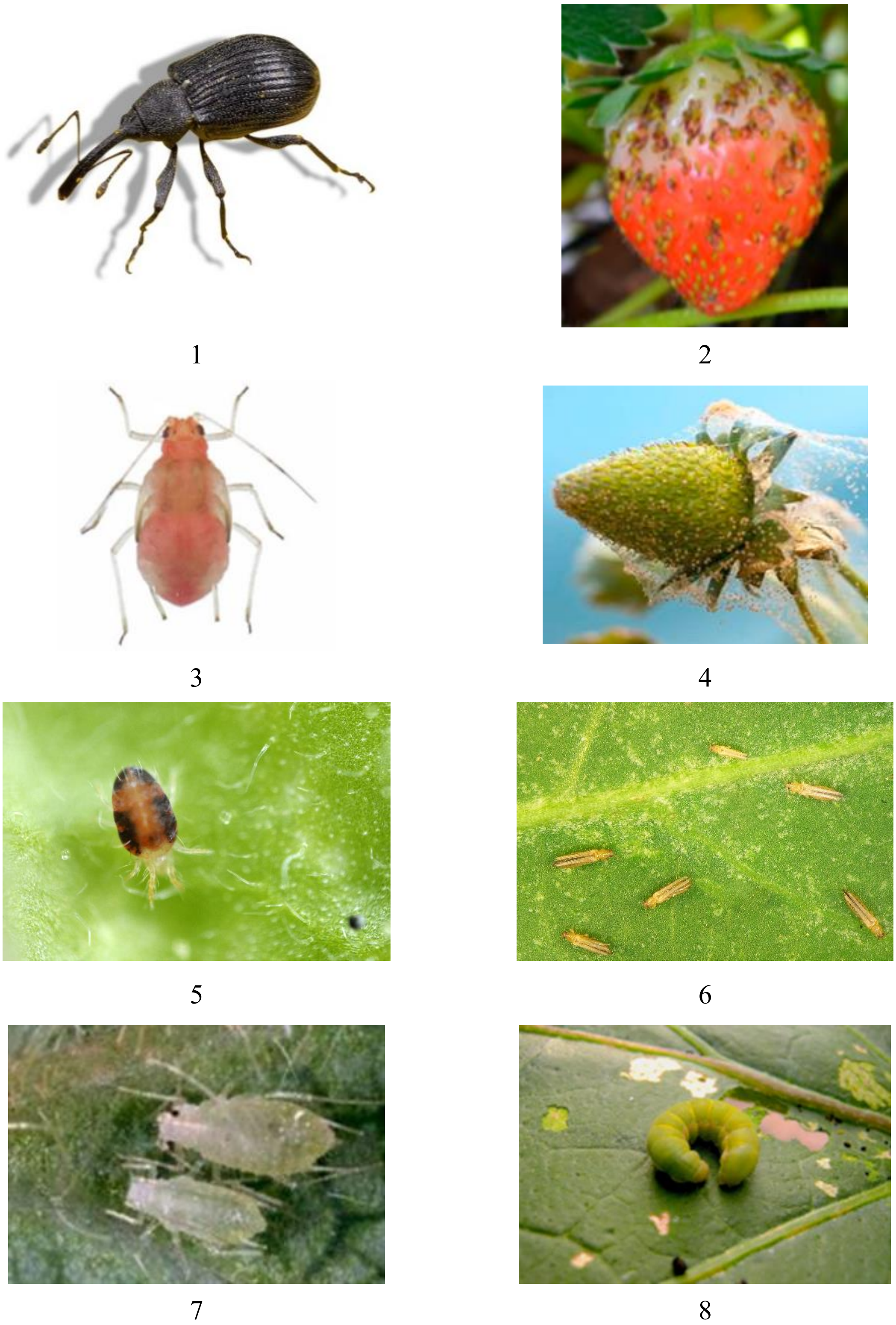

Fig. 3. Strawberry pests: 1) Anthonomus rubi; 2) Damage caused by A. rubi adults on strawberry fruit; 3)Myzus persicae; 4)Tarsonemus pallidus; 5) Two-spotted spider; 6) Thrips; 7) Aphis spp.; 8) Spodoptera exigua

The two-spotted spider mite can lay up to 200 eggs at a time, all of which will hatch and live on the strawberry plants throughout their adulthood. These pests are yellow and tiny, so they can be difficult to spot if you are just scanning the tops of the plants. They leave behind wispy webs all over the plants they invade, and they look more like fake cotton webs than actual spider webs. The damage from two-spotted spider mites can cause the strawberry plant to expand out of self-defense, but this is not necessarily a good thing. It can grow to a dangerous size and eventually become too weak to ward off other pests that come to feast on the leaves.

The strawberry mite develops about seven generations per year, which overlap and are harvested at harvest time, when maximum density is reached, all stages can be observed on the attacked plants - eggs, larvae and adults. It has a preference for young leaves with a delicate consistency. each one remains hidden in the rosette of the plants and causes damage only there. Depending on the degree of fall, crops can reduce their yield by 20 to 70-80%. The resulting fruits are of reduced quality - small and with a low sugar content, and in very severe cases they can dry out. Damaged leaves remain small and deformed, turn yellow and dry in dry weather or rot in wet weather. The thinning of the leaves leads to a decrease in nutrients in the rhizome and to poor bud formation in the first year. The symptoms resemble damage from stem nematodes and some viral diseases. The grown leaves are damaged, but mites cannot be found on them, which makes it difficult to identify the causative agent in a timely manner. The green peach aphid (Myzus persicae) is a common pest of strawberries that can cause significant damage. It feeds on the sap of the plants, which leads to leaf deformation, slowed growth and reduced yield. In addition, aphids are vectors of viral diseases that can further damage the crop.

Thrips are tiny yellow-brown insects, can be found on any part of the plant. When thrips feed on strawberry plants for long enough, they will cause multiple health issues for the crop. One is that the flowers will start browning prematurely and be unable to eventually become the fruitful blossoms that they need to be. Another effect is any fruit that does grow will be deformed from the start. Any strawberries that are directly attacked by thrips will typically be any combination of hard, dull, tiny, and unripe. When thrips invade in large numbers, they can ruin that year’s production of strawberry plants and therefore render the surviving strawberries unsalvageable .

The larvae of some ground insects, such as leafhoppers and other soil pests, damage the roots and base of the stem, which leads to the loss of the entire plant. Proper soil cultivation, crop rotation and, if necessary, soil insecticides are important for their management.

Spodoptera exigua poses a serious threat to strawberries because, due to warmer climatic conditions, it reproduces rapidly and causes significant damage to the crops. The larvae of Spodoptera exigua feed on the leaves of strawberry plants, leading to a loss of leaf mass and a weakening of the plants. Damage to the leaves and fruits results in a reduction in the quality and quantity of the harvest. In more severe cases, the pest can also damage the fruits themselves, rendering them unsuitable for consumption.

Spodoptera exigua reproduces quickly and can produce multiple generations within a single season, leading to a rapid spread of the population. In addition to strawberries, the pest can also feed on many other crops and weeds, which further complicates control. Spodoptera exigua is developing resistance to many pesticides, making its control even more difficult.

Integrated pest and disease management is the most effective approach. This includes a combination of agrotechnical practices (regular cleaning of plant residues, proper feeding), biological methods (use of beneficial insects) and limited use of chemical agents. The selection of resistant varieties and compliance with correct agrotechnical practices significantly reduces the risk of mass infections and attacks by pests.

Regular monitoring of crops allows for early detection of problems and timely response, which is essential for the successful discovery of strawberries. With proper application, you will be able to minimize all errors, and the harvest will be high-quality and abundant.

CONCLUSION

Proper crop management reduces the risk of infections. Integrated disease and pest management, which is a combination of biological, mechanical and chemical methods, gives the best results: crop rotation (not to plant strawberries after strawberries); the seedlings must be healthy and certificated; the varietal composition must be correctly chosen according to the conditions under which the crop is grown; to plant varieties that are resistant to most of the main pests in strawberries;

new plantations must be as distant as possible from old ones and free from soil pests that attack strawberries, including perennial weeds.Regular monitoring helps with early detection and rapid response and limitation of damage.

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MODELING OF FLUID TRANSPORT SYSTEMS IN MATLAB/SIMULINK/SIMSCAPE AREA[1]

Kaloyan Totev – PhD Student
Department of Heat, Hydraulics and Environmental Engineering,
University of Ruse "Angel Kanchev"
E-mail: ktotevk@gmail.com

Prof. Gencho Popov, PhD
Department of Heat, Hydraulics and Environmental Engineering,
University of Ruse "Angel Kanchev"
Phone: +359 82 888 580
E-mail: gspopov@uni-ruse.bg

Abstract: *The study outlines the stages involved in creating virtual test benches in the Matlab/Simulink/Simscape programming environment. Two virtual test benches for research have been synthesized using appropriately selected blocks: one for fluid transport systems and one for water level changes in two reservoirs, where water from one reservoir flows freely into the other. The operation of the second bench is simulated for a specific object, whose data is entered into an M-file. Graphics were obtained for the water flow rates supplied to the reservoirs, the change in the water level in them, and the time at which the fluid supply to the first reservoir stops. The mathematical model describing the operation of the test bench is presented.*

Keywords: *Pipe systems, Matlab/Simulink/Simscape, Modeling*

ВЪВЕДЕНИЕ

Програмният продукт Matlab разполага с множество математически методи, програмирани като готови функци, които позволяват решаването на широк кръг от задачи от областта на диференциалното и интегралното смятане, нелинейните системи, оптимизацията. Той е мощно средство за симулиране работата на реални системи.

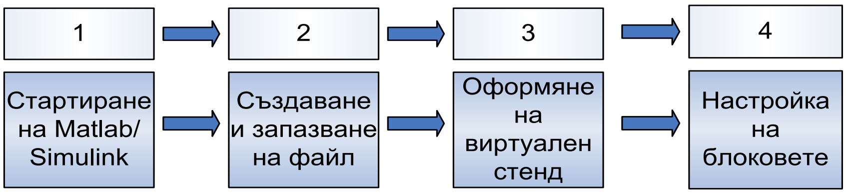
При моделиране на процесите, протичащи в системите за транспорт на флуиди, могат да се определят две стъпки. Първата е моделиране работата на отделните елементи – помпени агрегати, тръбопроводи, резервоари и др., а втората – настройването и интегрирането им (Ivanova D., Krasteva A., Andonov K., 2005). За целта могат да се ползват готови блокове от библиотеката SimPowerSystem (Krasteva A.,2020, Hristova M., Krasteva A., 2012), като трудност при настройването им е определянето на техните параметри. Съществуват разработки, в които се моделира работата както на използвания в електрозадвижващата система двигател (Krasteva A.,2020, Hristova M., Krasteva A. Ruseva V., 2013), така и на задвижвания обект (помпата) (Andrade-Cedeno, R.J. et al., 2022). Алтернативен подход за решаване и анализ на хидравлични тръбни мрежи в Matlab/Simscape е представен в (Gérémino Ella Eny et al., 2024), който се състои в намиране на необходимия дебит на източниците при известна топография на хидравлична мрежа. С използване възможностите на високо развитите компютърни технологии и достъпните програмни продукти за създаване на модели, визуализиране и симулиране работата на различните видове системи за транспорт на флуиди е анализиран и оптимизиран разходът на електрическа енергия в тях (Dinolov O., 2011).

Целта на настоящата работа е в средата **Matlab/Simulink/Simscape** да се синтезират виртуални стендове за изследване: на системи за транспорт на флуиди и изменението на нивото на водата в два резервоара, при свободно ѝ изтичане от първия към втория.

[1] Докладът е представен на студентската научна сесия на АИФ на 08.05.2025 г. с оригинално заглавие на български език: МОДЕЛИРАНЕ НА СИСТЕМИ ЗА ТРАНСПОРТ НА ФЛУИДИ В СРЕДАТА MATLAB/SIMULINK/SIMSCAPE.

ИЗЛОЖЕНИЕ

Етапите при създаване на виртуален стенд за изследване на системи за транспорт на флуиди в средата на Matlab/Simulink/Simscape са визуализирани чрез блокова схема на фиг. 1. При оформянето на стенда, необходимите блокове от библиотеката Simulink/ Simscape се разполагат в работното пространство на новосъздадения файл, надписват се и се настройват.

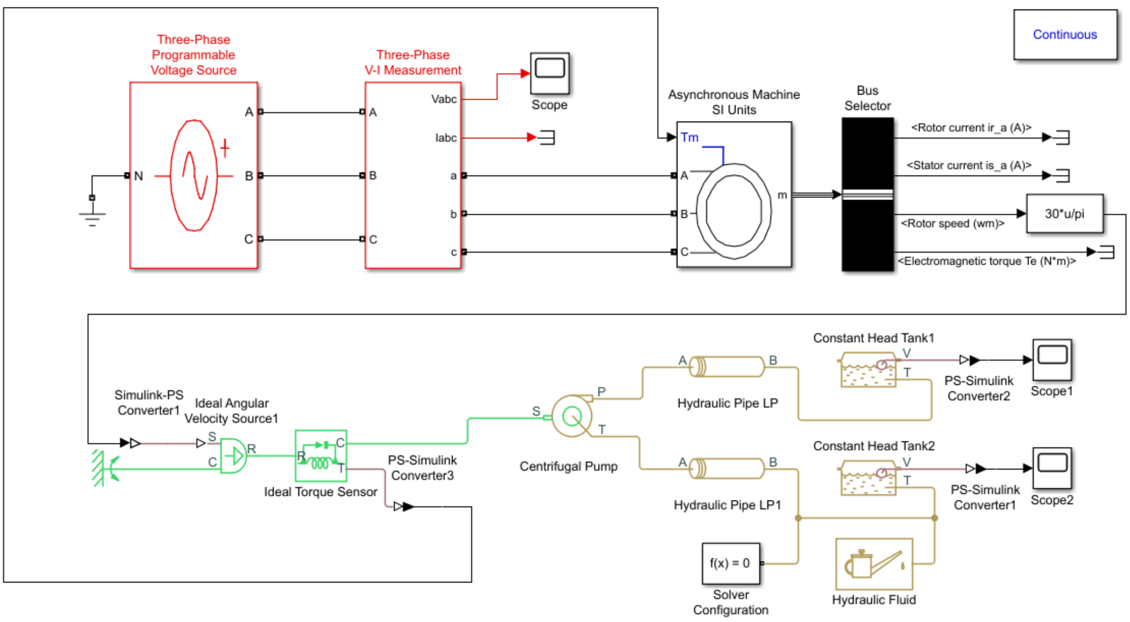


Фиг. 1. Етапи при създаване на виртуален стенд в средата на **Matlab/Simulink**

Чрез подходящо подбрани блокове от програмната среда Matlab/Simulink/Simscape, в разработката са синтезирани два виртуални стенда за:

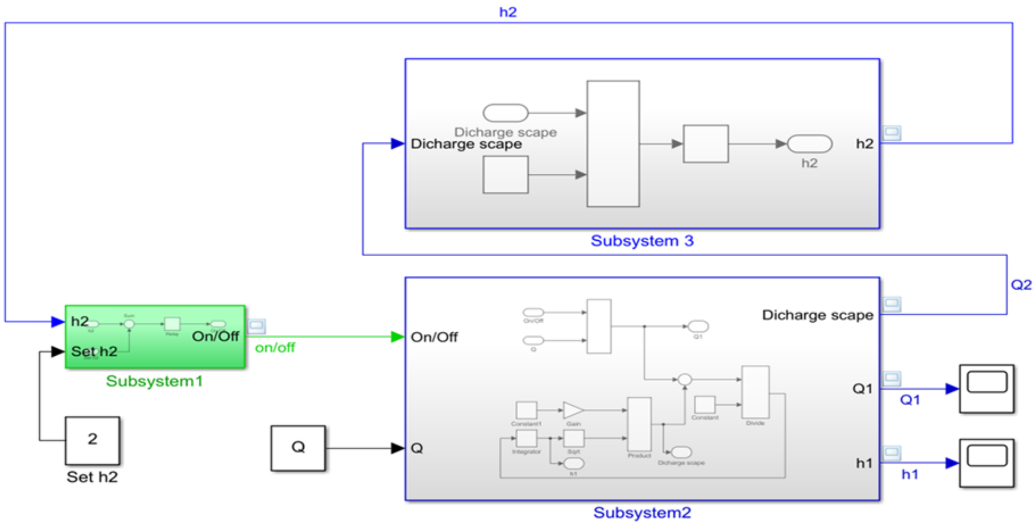
- изследване на системи за транспорт на флуиди;
- изследване изменението на нивото на водата в два резервоара.

Виртуалният стенд (фиг. 2) за изследване на системи за транспорт на флуиди е разработен с помощта на програмния продукт Matlab и приложенията Simulink/Simscape като се използват следните блокове (https://www.mathworks.com): Asynchronous Machine SI Units – готов модел (блок) на трифазна асинхронна машина; Three-Phase Programmable Voltage Source – източник на трифазно променливо напрежение; Three-Phase V-I Measurement за измерване на трифазното напрежение и ток; Bus selector – на изхода му се получават стойности за честотата на въртене на вала на двигателя и електромагнитния момент; Scope, Scope 1, Scope 2 – осцилоскопи за визуализиране на захранващото линейно напрежение на асинхронния двигател, нивото на водата в резервоар 1 (Tank 1) и резервоар 2 (Tank 2); Ideal Torque Sensor – преобразува променлива, преминаваща през сензора, в управляващ сигнал, пропорционален на въртящия момент; Centrifugale pump –центробежна помпа; Solver Configuration – определя параметрите на виртуалния модел преди стартиране на симулация; PS-Simulink Converter – преобразува физически сигнал в изходен сигнал на Simulink; Hydraulic Fluid – посочва типа хидравлична течност, използвана в цикъл от хидравлични блокове. Представеният на фиг. 2 стенд за изследване на флуиди е структуриран от различни обекти: захранващ блок, асинхронен двигател; центробежна помпа; напорни и смукални тръбопроводи; резервоари.



Фиг. 2. Виртуален модел за изследване на система за транспорт на флуиди

Създаден е виртуален стенд – фиг. 3, за изследване изменението на нивата на водата в два резервоара, като тя се изтича свободно от първия във втория чрез тръба, чието сечение се означава с a_1, m^2. Той се състои от три подсистеми, означени на фиг. 3 и показани на фиг. 4 като: Subsystem 1, Subsystem 2, Subsystem 3. Настройването на блоковете, използвани в тях, е описано подробно в (https://www.mathworks.com).



Фиг. 3. Виртуален модел за изследване на нивата на водата в два резервоара

Математичният модел, с който се описва работата на стенда, е:

$$A_1 \frac{dh_1}{dt} = Q_1 - a_1\sqrt{2g(h_1(t))}; \qquad (1)$$

$$A_2 \frac{dh_2}{dt} = a_1\sqrt{2g(h_2(t))} \qquad (2)$$

където A_1 е площта на резервоар 1, m^2;

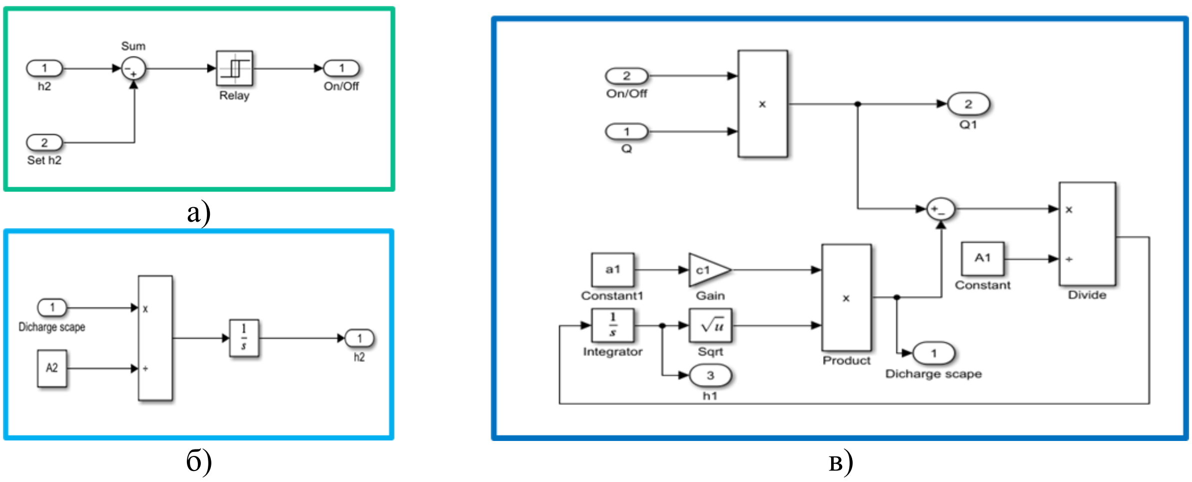
A_2 – площта на резервоар 2; m^2

h_1 – нивото на водата в резервоар 1, m;

h_2 – нивото на водата в резервоар 2, m;

Q_1 – дебитът на водата, подавана към втория резервоар, m^3/s;

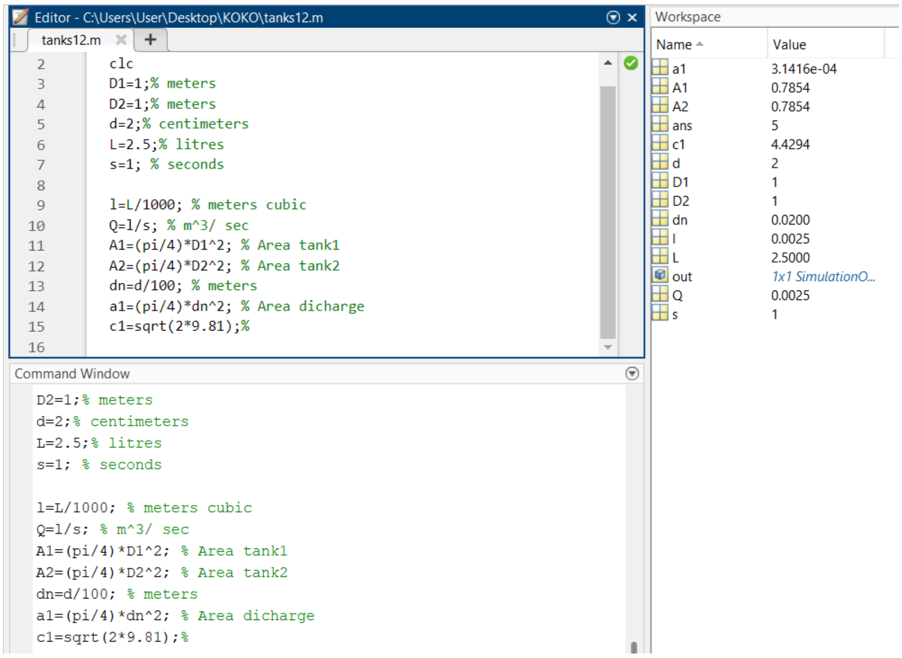
g – земното ускорение m/s^2.



Фиг. 4. Виртуални модели на: а) Subsystem 1; б) Subsystem 3; в) Subsystem 2

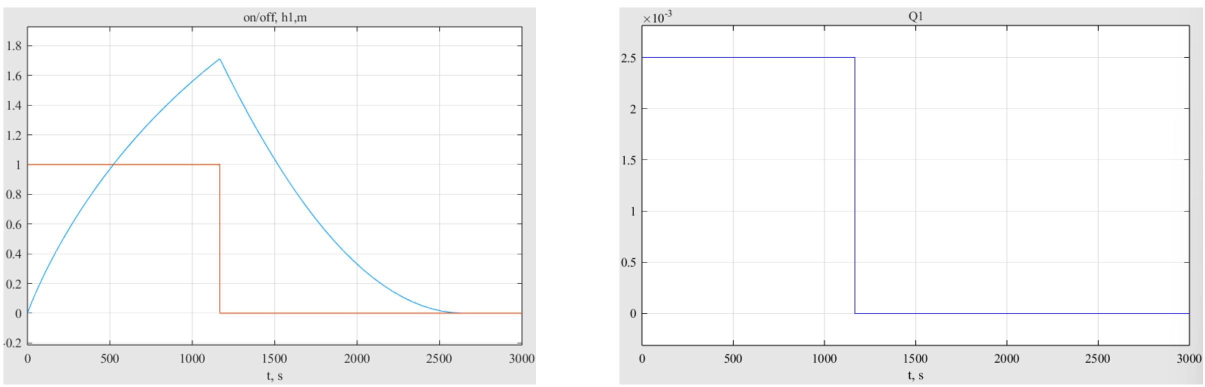
Първата подсистема е управляваща и определя момента, в който се преустановява подаване на вода към първия резервоар. В настоящия модел това става, когато нивото на водата във втория резервоар стане 2 m. Условието може да бъде променено, ако в блока Set h_2 (фиг. 3) се въведе друга стойност. Дебитът, подаван в Subsystem 2, е означен с Q.

Данните за изследвания обект и необходимите за целите на изследването изчисления се въвеждат в М-файл в средата Matlab. Преди стартиране на симулацията на виртуалния стенд от фиг. 3, те се зареждат в работното пространство, както е показано на фиг.5. Използвани са следните означения: D_1, D_2 – диаметри на двата резервоара, d – диаметър на тръбата, от която водата се изтича от първия към втория резервоар, L – дължината ѝ.



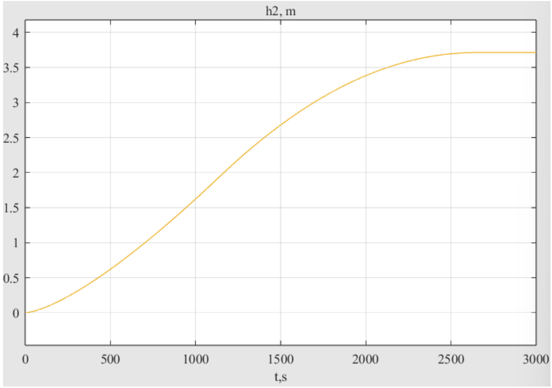
Фиг. 5. М-файл (tanks12 m) и данни за изследвания обект, визуализирани в работното пространство Workspace

Чрез моделите Subsystem 2, Subsystem 3 могат да се наблюдават измененията на: дебитите на водата към първия и втория резервоар и изменението на нивата ѝ. На фиг. 6 е показан моментът на включване на системата, h_1 – нивото на водата в резервоар 1, m; Q_1 – дебитът на водата, подавана към втория резервоар, m^3/s, а на фиг.7 – h_2 (нивото на водата в резервоар 2), m.



а) б)

Фиг. 6. Изменение на: а) h_1 – нивото на водата в резервоар 1; б) Q_1 – дебитът на водата, подавана към втория резервоар, m^3/s.



Фиг. 7. Изменение на нивото на водата в резервоар – h_2, m

ИЗВОДИ

Създаден е виртуален стенд за изследване на системи за транспорт на флуиди в средата Matlab/Simulink/Simscape. Използвани са готови блокове от програмната среда, с въведените в тях параметри.

Създаден е виртуален стенд за изследване на нивото на водата в два резервоара, при свободно изтичане на вода от първия към втория. При конкретни данни за обекта, представени в М-файл, е симулирана работата на стенда. Чрез моделът може да се наблюдават (визузлизират) дебитите, постъпващи в двата резервоара, нивата на водата в резервоарите, както и моментът на включване/изключване на стенда. Моделите са основа за разработване на виртуален стенд в Matlab/Simulink/Simscape за оценка на енергийната ефективност на помпени/водоснабдителни системи.

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THU-SSS-THPE-02

FLOOD RISK MAPPING IN BISKRA CITY USING REMOTE SENSING AND GIS TECHNOLOGIES

Billal Kheloufi, PhD student in Hydraulic
Department of Civil Engineering and Hydraulics, Faculty of Sciences and Technology, University of Biskra, Algeria
E-mail: billal.kheloufi@univ-biskra.dz

Hachemi Ali, professor in Hydraulic
Ecology of Arid Ecosystems and Climate Risks Division, Scientific and Technical Research Center on Arid Regions, CRSTRA Biskra
E-mail: alihachemi.hyd@gmail.com

Leila Mimeche, PhD in Hydraulic
Department of Civil Engineering and Hydraulics, Faculty of Sciences and Technology, University of Biskra, Algeria
E-mail: l.mimeche@yahoo.fr

Meriem Boultif, PhD in Hydraulic
Ecology of Arid Ecosystems and Climate Risks Division, Scientific and Technical Research Center on Arid Regions, CRSTRA Biskra
E-mail: boultif.meriem05@gmail.com

Abstract: *Floods in all their form are considered a real threat to many regions of the world. There are various types of floods, including those caused by the collapse of dams. Urban flooding is the most common and destructive type of natural disaster. One effective strategy for managing and mitigating such floods involves using flood risk maps to support informed decision-making. This study focuses on the delineation of the flood plain area caused by Manbaa-Al-Ghozlan dam failure in the city of Biskra using the HEC-RAS 2D for hydraulic modeling, and evaluating three key aspects of urban flooding: exposure, vulnerability, and overall flood risk, resulting from a potential failure of the Dam located upstream of the city. A multi-criteria decision-making (MCDM) approach was employed to carry out the assessment. Six factors were considered in determining vulnerability: land use, proximity to major watercourses (Oued), nearness to drainage convergence zones, elevation, population density, and distance from primary roads. Each factor was weighted based on its influence on flood vulnerability. The final flood risk map was developed by integrating hazard and vulnerability data, enabling assessment of potential damage and economic impact. The map categorizes risk into four levels: very high, high, moderate, and low. Findings show that over 63% of the study area falls within the high-risk category, with water depths potentially exceeding 10 meters in the event of dam failure. This map serves as a valuable decision-support tool for managing flood risks in arid and semi-arid regions.*

Keywords: *HEC-RAS 2D, Dam-breach, Remote sensing, Multi-criteria decision-making (MCDM), Flood risk mapping.*

INTRODUCTION

Flash floods are among the most dangerous natural hazards due to their severe social, economic, and infrastructure impacts, particularly in developing countries (Da Silva et al., 2020). Understanding the physical and spatial characteristics of risk factors like exposure and vulnerability is essential for effective flood prevention (Tanoue et al., 2016). This makes flood assessment and mitigation a critical challenge, especially in arid regions. Globally, several dam-related flood disasters have occurred, including the 1979 Machu dam failure in India, which resulted in 5,000 casualties (Lempérière, 2017).

Flood risk analysis linked to dam failure has gained attention recently, due to growing urban development near reservoirs (Bales et al., 2001; Balogun & Ganiyu, 2017; Butt et al., 2013). The complexity of flood control, involving many stakeholders and technical challenges, requires integrated approaches like multi-criteria decision-making (MCDM) (Kopackova et al., 2007).

MCDM tools, such as AHP-GIS, are widely used to identify flood-prone areas using various factors like precipitation, slope, drainage, elevation, and land use (Armenakis & Nirupama, 2014).

Despite being highly vulnerable to climate variability, Algeria has limited knowledge and preparedness regarding flash floods (Sumi et al., 2022). The country has faced both prolonged droughts and urban expansion, often encroaching on natural waterways. In many areas, channels have been rerouted, filled, or piped, as observed in the study area. Biskra, a rapidly growing city in southeastern Algeria, lies along a major watercourse and has suffered significant flood events. This study therefore aims to assess and map flood risks resulting from a potential failure of the Gazel Fontaine Dam, located about 40 km upstream of Biskra.

METHODOLOGY

Case Study

Biskra City is located in southeastern Algeria, between latitudes 34.877° – 34.822° N and longitudes 5.799° – 5.706° E. It lies 205 km inland from the Mediterranean Sea, separated by mountainous and highland terrain, and is characterized by a dry climate with marked seasonal variations. The average annual temperature is 20.05 °C, ranging from 3.75 °C in December to 41.54 °C in July. Annual rainfall averages 307.69 mm, with precipitation levels varying between 6.81 mm in July and 36.82 mm in November (Benedib, 2021). The region sits at an elevation of 177 meters above sea level and features flat terrain with minimal slope (Fig. 1).

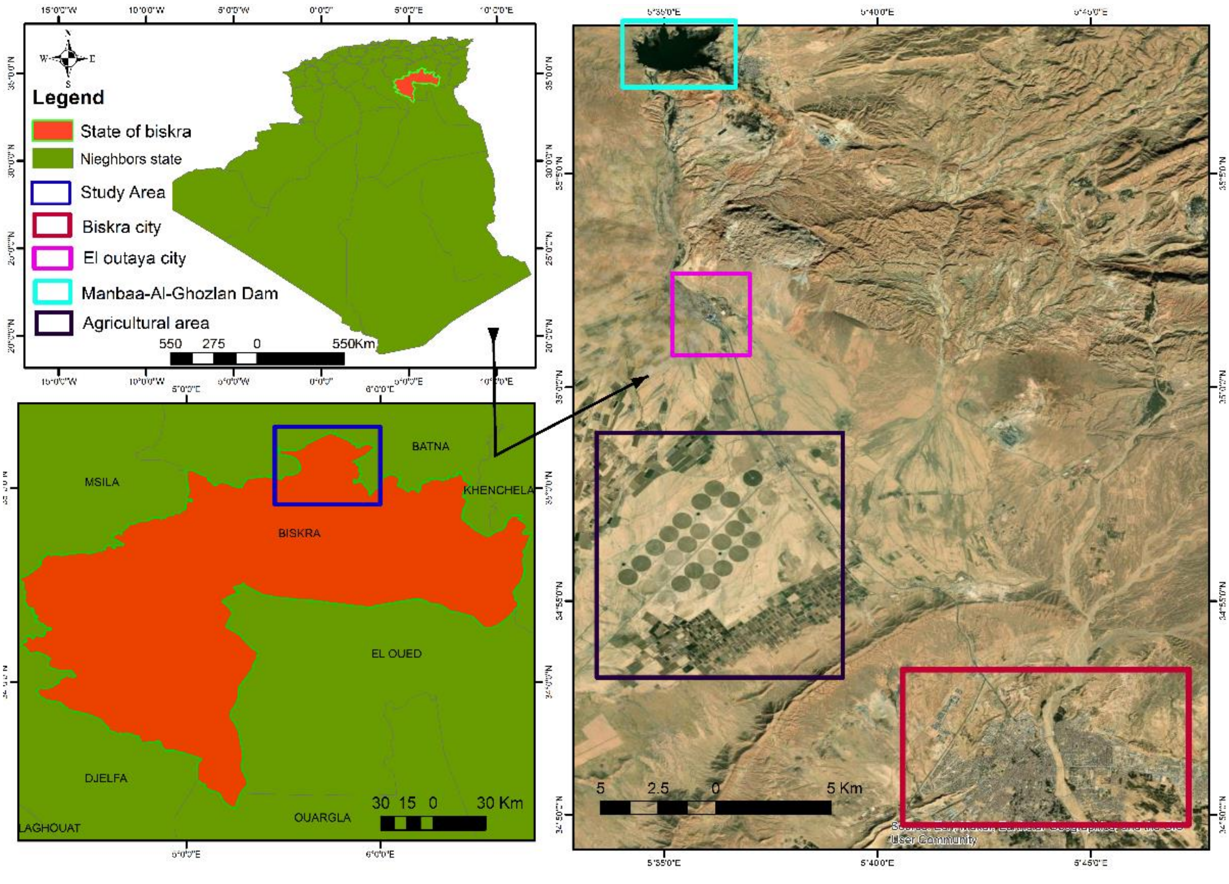

Fig. 1. Geographical location of the study region

Biskra is positioned at the base of the Aurès Mountains, 40 km downstream from the Gazelle Fountain Dam, which has a storage capacity of 55.49 hm³. The city lies at the junction of Wadi El-Hai and Wadi Djemora, which merge to form Wadi Biskra running through the city center. Rapid population growth has driven urban expansion, particularly near Oued Biskra, resulting in disruption of the wadi bed and a reduction in rangeland and bare soil areas between 2003 and 2020 (Boumsenegh, 2007) (Fig. 2).

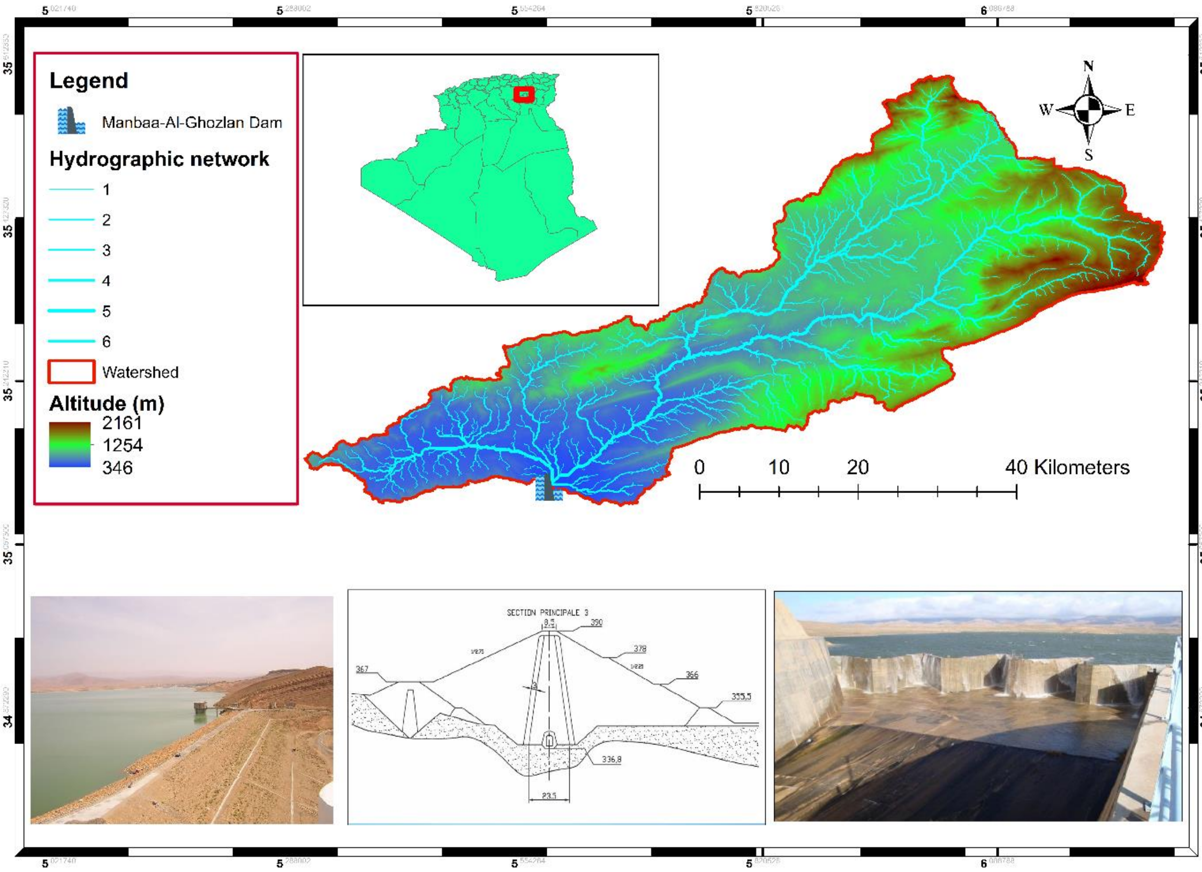

Fig. 2. Manbaa-Al-Ghozlan Dam (Watershed; Localization ; Dike and Spillway)

The Gazelle Fountain Dam is an earth-fill structure measuring 385 meters in length and 42.5 meters in height (crest elevation: 390 NGA), with an initial capacity of 55.49 hm^3. It was completed in 2000 and became operational in 2006 to manage flooding from Oued El-Hai and support irrigation for over 1,100 hectares in the El-Outaya region (NASP, 2003). The dam is fed by Oued El-Hai and Oued Tamtam, located at elevations between 347 m and 2134 m, with an annual flow exceeding 20 hm^3. The watershed spans two climatic zones, covering more than 175,871 hectares. a desert zone in the province of Biskra and a semi-arid zone in Batna, each with an area of 32.739.71 ha. This region is characterized by a flat terrain, of which 74.25% do not exceed 12 °C, while 25.75% of the watershed has slopes greater than 12°C (Bendib, 2021).

Hydraulic modeling

Modeling is about reproducing, as much as possible, the course of a real process (Kepa, 2021). The hydraulic model is a simplified representation of a hydraulic phenomenon; it is based on the resolution of fluid flow equations at the level of artificial or natural channels. The efficiency and precision of the calculations will depend directly on the quality of the basic data. In this work, we will use HEC-RAS (Hydrologic Engineering Center River Analysis System) (version 6.1) software to Modeling; this choice depends on the availability, simplicity, and quality of the exploitable and interpretable results that are provided by this software. The model is capable of simulating 2D flow, which gives it an advantage for estimating flood inundation. The model was developed based on the full 2D St. Venant equations, solved using a finite difference scheme (Yakti et al., 2018).

Hazard Simulation

The HEC-RAS hydrodynamic model is used to create a flood exposure map for overflowed dam failure scenarios. The water level in the dam is supposed to be at a normal level when a flood with peak discharges of 4500 $m^3.s^{-1}$ occurs, which is more than 1.5 times the total discharge capacity of the dam spillway. The breach parameter of the scenario is estimated according to Froehlich (2008).

Vulnerability Assessment and Input Criteria

The GIS tool was used here to collect and proceed with six (6) different thematic layers according to their weights: Landuse, distance from the main watercourse (Oued), distance from the drainage accumulation, Elevation, population density and distance from the main roads (Figure 4).

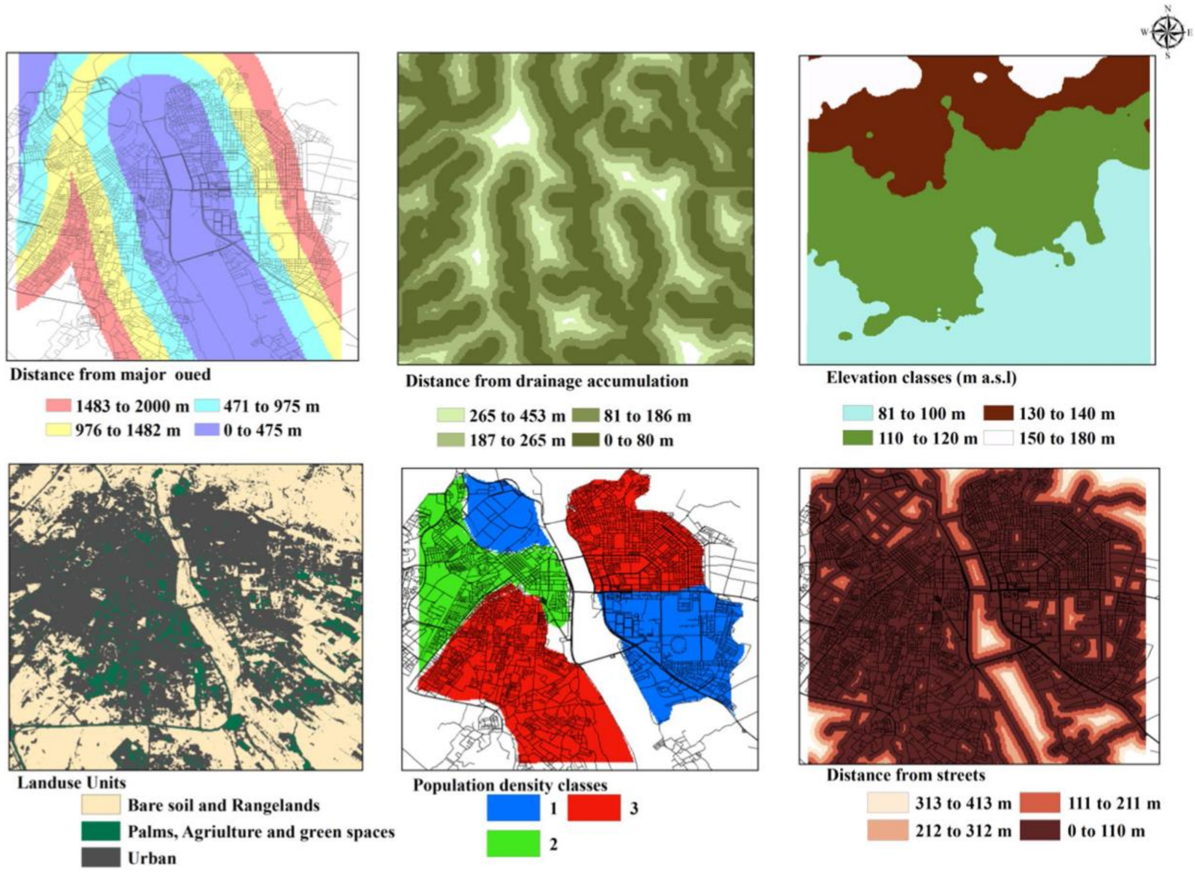

Fig. 3. Input Criteria

Flood Risk Calculation

The above criteria will undergo an AHP (Saaty, 1988); this approach can be used to derive flood priorities from a matrix of pairs of comparative flood judgments that lead to weighting each criterion based on its impact on vulnerability to urban flooding. The final flood map was derived from the sum of the weights multiplied by the rate of each criterion (factor) (Kittipongvises et al., 2020); the main advantage of using the AHP pair comparison method is the ability to obtain a reliable vulnerability and more flexible and easier to update the map (Kittipongvises et al., 2020), the degree of vulnerability to flooding is calculated as:

$$\text{Risk} = \text{Vulnerability} * \text{Hazard}$$

Both vulnerability and hazard maps underwent a fuzzy membership analysis before multiplying the two layers using the raster calculator tool in ArcGIS software; the MSlarge membership was used because higher values of vulnerability and hazard indicate a higher risk value.

RESULTS AND DISCUSSION

Vulnerability Map

The assigned weights to each criterion, were used in a weighted sum approach using ArcGIS 10.4 software in order to estimate flash flood vulnerability; the result is a classified map according to pixel values into four different vulnerability classes: The low vulnerability class Occupies 7.24%; these areas are mainly situated away from the city center and the dense urban network and from flow accumulation areas. Moderate vulnerability Areas occupy nearly 25,24% of the city area; these areas are relatively distant from the major waterway (Oued Biskra) but are relatively of low elevation and characterized by a high population density and a denser road network; this area is a part of the old city were the houses and especially the road network are less developed. High vulnerability class occupies 27 28%, characterized by a higher population density, commercial activity and popular markets, situated on low elevation around the city centre are the old city; old houses are concentrated in this area, some of which are over a hundred years old. Areas of very high vulnerability occupy 40, 24% of the study area, mainly around the significant watercourse (Oued) and in areas of higher density, situated in the centre of the old city, and on the El Alia section. In addition to high population density, these areas are characterized by narrow, bifurcated roads and overlapping buildings, especially in the Old city, making intervention in the event of a flood very difficult (figure 4a).

Hazard Map

In case of a dam failure, a submerged area measuring 13.21 km^2 becomes a critical concern; the water depth in some parts of the city of Biskra can reach a staggering 43 m, posing a significant threat to residents. Within the submerged area, approximately 12.85% (1.68 km^2) experiences water depths between 0 and 1.8 m notably some parts of the old city. Another 11.32% of the total emerged area (1.48 km^2) will potentially be emerged by 1.9 to 5 m of water around the city centre, the equipment area, and the train station. While water could reach from 5 to almost 43 m of depth on 9.6 km^2 of the submerged surface which is more than 70% of the total area; this part presents one of the largest population density centres in the city mainly near the major Oued where the depth ranges between 11 and 43 m (Haret El Oued Area), as well as El Alia section that contains the principal hospital, the central university and many administrative buildings (Figure 4b).

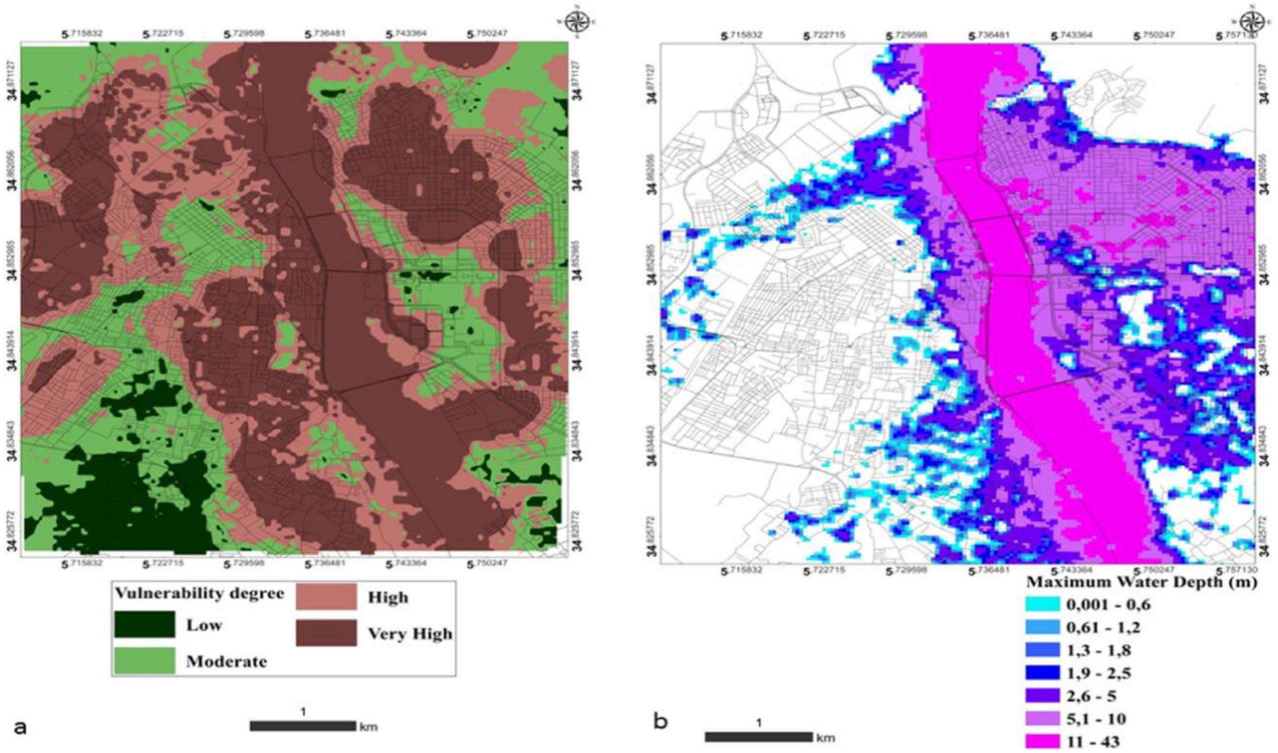

Fig. 4. Output maps; a) Vulnerability map, b) Exposure map

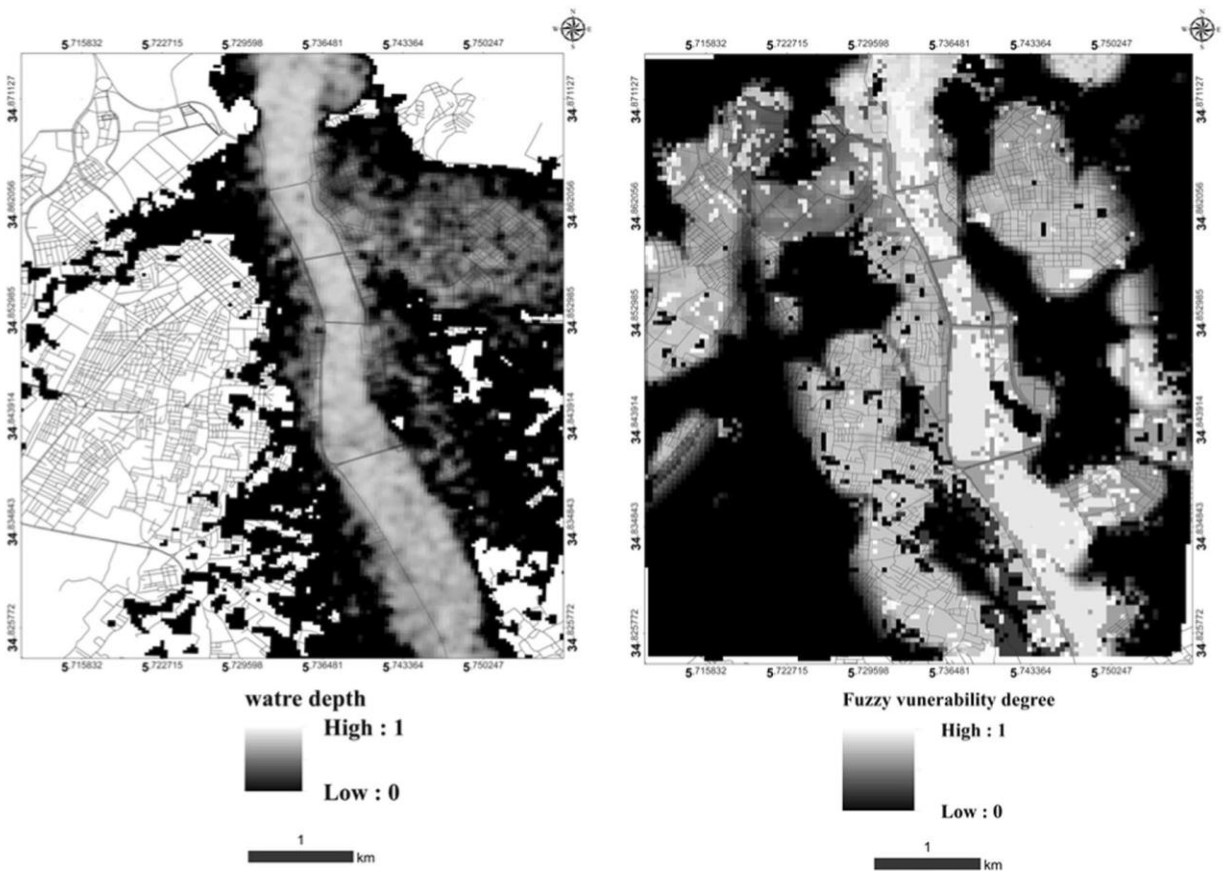

Fig. 5. Fuzzified vulnerability and hazard map

Risk Map

The risk is the result of vulnerability and exposure multiplication. For this, these two factors were mapped and then fuzzified before the risk calculation (Fig. 6). The risk-situated zone covers an area of 2.84 km^2. Within this zone, approximately 22.25% is classified as a low-risk zone, making it relatively safer in case of potential hazards, mainly far from the city centre, the major Oued and on the peripheries of the El Alia section. Areas of moderate risk occupy 14.27% of the zone, indicating a need for cautious monitoring and planning, mainly on some parts of the old city and the Northern part of El Alia (residential neighbourhoods). The equipment zone is also within this area, it has a significant economic importance, due to the factories and warehouses located there, in addition to the railway and the train station, which is a vital centre for the logistics supply in the region. Conversely, high and very high-risk regions, spanning 8.12 km^2, constitute a significant 63.48% of the risk-prone surface. These areas pose substantial threats to the population due to their situation on mainly residential neighbourhoods. It is crucial to implement robust safety measures and emergency preparedness in these regions, considering their dense population. Notably, this high-risk area is inhabited by tens of thousands of people, as well as many popular markets, shops and several vital infrastructures, including the principal hospital, children and maternity hospital, the central university, banks, hotels, schools, health institutions, and an administrative district that houses numerous government buildings.

The concentration of essential facilities further underscores the need for disaster resilience planning and mitigation strategies (Figure 6b).

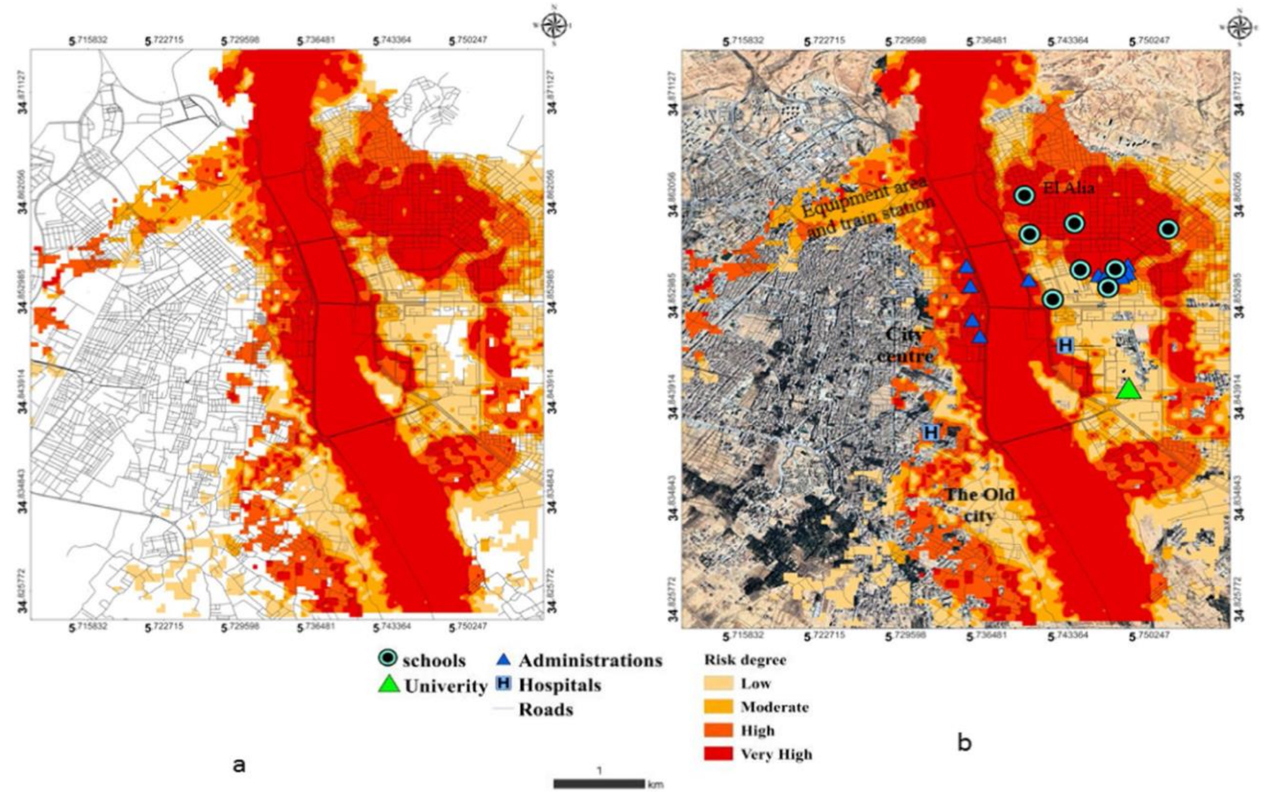

Fig. 6. Output risk map, a extension of risk degree, b risk degree and susceptible damaged facilities

CONCLUSION

The main objective of this study was to assess and spatially depict the flash flood risk degree within the city of Biskra, situated in the South East of Algeria, through a comprehensive mapping of vulnerability and exposure factors. Employing a GIS-based methodology, the research utilized the AHP multicriteria analysis to evaluate six pivotal factors, which played a crucial role in determiningvulnerability. Additionally, a HEC- RAS simulation was employed to assess exposure, specifically evaluating water depth and potential flooding areas in the event of dam failure. The outcomes of this analysis yielded two crucial maps, a vulnerability map and an exposure map.

The results show that the risk area is located on a surface of 2.84 square kilometres, of which, the majority are located in the El Alia region and adjacent areas of the water stream (Oued Biskra). Some parts of the Old City are located in areas of moderate risk due to the old age and the fragility of buildings, in addition to the equipment area, which is dedicated to industry and storage; it has a critical economic importance, as well as the train station, making it necessary to intervene in order to protect this area. Al-Alia region in the northeast is mostly situated at high and very high-risk areas; it is a highly populated section of Biskra. El Alia also includes many administration facilities, infrastructure, residential buildings, shops and a popular market. Haret El Oued region is also a classified area with a high risk due to its alignment with the main water stream, its low altitude and its containment of a large number of ancient popular homes, residential buildings and several important facilities such as the city's main post centre, court and general police directorate.

The main purpose of developing these comprehensive maps is to provide stakeholders with an effective decision-making tool, facilitating their tasks in devising optimal management plans. Additionally, these maps serve to communicate the risk situation prevailing in various parts of the city and to caution against the haphazard expansion of residential neighbourhoods near the mainstream of the oued; by providing essential insights into flood risk, this research aims to promote informed decision-making and proactive urban planning to enhance the city's resilience to flash floods.

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THU-SSS-EC-01

BIOFERTILIZERS AND SUSTAINABLE CULTIVATION OF LEGUMINOUS CROPS IN THE CONDITIONS OF SOUTHEASTERN KAZAKHSTAN: ECOLOGICAL AND AGRONOMIC ASPECT

Zhanna Zhumabek – Student / PhD Student
Department of Soil Science, Agrochemistry and Ecology,
Kazakh National Agrarian Research University
Tel.: +7 702 358 0804
E-mail: zhanna.zhumabek@gmail.com

Assoc. Prof. Margarita Vasileva Filipova, PhD
Department of Heat, hydraulics and environmental engineering,
University of Ruse "Angel Kanchev"
Phone: +359 88 730 8311
E-mail: mfilipova@uni-ruse.bg

Assoc. Prof. Anarbekova Gulshat
Institute of Natural Sciences,
Kazakh National Women's Teacher Training University
Phone: +7 702 899 2101
E-mail: gulchi_09@mail.ru

Abstract: *Modern agriculture faces the challenge of soil degradation caused by excessive use of mineral fertilizers, irrational agronomic practices, and climate change. This review article examines the impact of leguminous crops (Cicer arietinum, Lens culinaris, Pisum sativum) on improving soil characteristics and the potential of using biofertilizers under rainfed farming conditions in Southeastern Kazakhstan.*

An analysis of global scientific literature shows that the inclusion of legumes in crop rotation promotes atmospheric nitrogen fixation, improves soil structure, and reduces dependency on synthetic fertilizers. The paper reviews studies conducted in various regions, including Iran, Russia, and Kazakhstan, confirming the effectiveness of biological fertilizers—with properties similar to BioAzoPhosphite, Bioprotect, and Trihoderma Fighter—in increasing crop yields and enhancing soil fertility.

Based on existing research, the article substantiates the necessity of studying these leguminous crops and biofertilizers in the agro-climatic conditions of Southeastern Kazakhstan. Future research is aimed at assessing the effects of biopreparations on soil characteristics, microflora, and crop productivity, which will allow the development of recommendations for their effective use in sustainable agriculture in the region.

Keywords: *soil degradation, leguminous crops, biofertilizers, nitrogen fixation, rainfed agriculture, Southeastern Kazakhstan.*

INTRODUCTION

Chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), and pea (*Pisum sativum*) are key leguminous crops that play an important role in ensuring food security and nutrition. Due to their high content of plant-based protein, vitamins, and micronutrients, as well as their ability to fix atmospheric nitrogen, these crops help reduce anthropogenic pressure on ecosystems [1]. Within the framework of sustainable agriculture, they are considered tools for the biological intensification of farming and restoration of soil fertility [1].

However, the productivity of legumes largely depends on agroecological conditions, including water availability, soil type, and levels of agrochemical stress. Southeastern Kazakhstan is a region of rainfed agriculture characterized by low precipitation, dry summer periods, and a moderately continental climate. The dominant soils are light chestnut and sierozem (gray soils), which are low in humus and prone to degradation. Under these conditions, it is critically important to implement adapted agrotechnologies that improve nutrient efficiency and stress tolerance. One such solution is the use of biofertilizers—biological preparations containing beneficial microorganisms that enhance nutrient availability and protect plants from pathogens.

Biofertilizers such as "BioAzoPhosphite," "Bioprotect," and "Trichoderma Fighter," produced in Kazakhstan, are intended for seed inoculation and plant treatment to improve nutrition and protection. These formulations are presumed to contain a combination of nitrogen-fixing bacteria (e.g., rhizobia), phosphate-solubilizing microorganisms, and antagonistic fungi of the *Trichoderma* genus. It is known that *Trichoderma* strains are capable of synthesizing phytohormones and stimulating plant growth, making them effective biofertilizers and biostimulants for agricultural crop development [2]. Below is a review of studies on the effects of such biofertilizers on the planting and yield of chickpea, lentil, and pea, as well as an analysis of current cultivation challenges and a discussion of their importance for sustainable agriculture.

EXPOSITION

Biofertilizers and the Yield of Chickpea, Lentil, and Pea

Chickpea is an important food and fodder crop known for its ability to form symbiosis with nodule bacteria and its high drought tolerance. However, to realize the yield potential of chickpea, adequate nitrogen and phosphorus supply is essential, along with protection against pathogens during the early growth stages. Traditionally, chickpea seeds are inoculated with rhizobia (*Mesorhizobium ciceri*) prior to sowing, promoting the formation of a greater number of nitrogen-fixing nodules. Experimental data indicate that the use of effective rhizobial strains can significantly increase chickpea grain yield compared to untreated controls [3]. Additionally, the use of phosphorus-containing biopreparations (phosphate-mobilizing bacteria) and biocontrol agents has a synergistic effect. According to field trials in Punjab (India), the highest chickpea yield (~1.81 t/ha) was achieved through the combined application of 100% phosphorus along with inoculation using rhizobia, phosphate-solubilizing bacteria (*Pseudomonas*), and *Trichoderma* fungi [4]. In this integrated treatment, significant improvements were observed in chickpea agronomic traits: increased plant height, number of branches and nodules, dry matter weight, pod count per plant, and 100-seed weight [4]. Such a technology, similar to the use of "BioAzoPhosphite" (nitrogen-fixing and phosphate-mobilizing bacteria) in combination with "Bioprotect" and *Trichoderma*, can result in yield gains and is recommended for adoption [4]. Besides improving yields, chickpea inoculation with biofertilizers contributes to sustainable farming by reducing the need for mineral nitrogen and increasing fertilizer efficiency.

Lentil is a valuable pulse crop widely cultivated in temperate and subtropical regions. It forms symbiosis with *Rhizobium leguminosarum*, but the efficiency of biological nitrogen fixation depends on the presence of effective strains in the soil. In practice, seed inoculation with specialized rhizobia is often justified even in fields with a history of legume cultivation. A recent multi-year study in the North American plains showed that lentil inoculation resulted in an average grain yield increase of approximately 344 pounds/acre (~0.38 t/ha) in 30% of trials, and in no case was a yield decrease observed compared to the uninoculated control [5]. This confirms the appropriateness of using rhizobial inoculants: even if the effect is not always pronounced (depending on weather and soil conditions), inoculation remains a cost-effective insurance practice for nitrogen nutrition in lentil.

In addition to nitrogen-fixing bacteria, other microbial preparations also positively influence lentil. In particular, *Trichoderma*-based biofungicides can stimulate growth and productivity. Field trials have shown that treating lentil seeds with certain *Trichoderma* strains significantly enhanced plant growth and seed mass per plant. For example, inoculation with *Trichoderma* strain TH1 led to a 169% increase in seed mass per plant compared to the control [6]. Other Trichoderma strains also showed significant yield increases: seed mass per plant increased by 53–112% depending on the isolate used [7]. These results highlight the strong biostimulant effect of *Trichoderma* on lentil, expressed in improved yields. The product "Trihoderma Fighter," containing highly active *Trichoderma* strains, is potentially capable of providing similar gains by improving the phytosanitary condition of crops (through suppression of soil pathogens) and stimulating root development. Integrated use of rhizobial inoculants and biocontrol agents (*Trichoderma*, *Pseudomonas*, etc.) in lentil may become a component of a resource-efficient agrotechnology that enhances yield without increasing mineral fertilizer use.

Pea is a traditional temperate-zone legume widely used as both food and feed. As a legume, pea can meet a significant part of its nitrogen needs through symbiosis with nodule bacteria (*Rhizobium leguminosarum*). In cultivated fields with a history of legume production, the native rhizobial background often ensures satisfactory nitrogen fixation. However, in new territories or where legumes have not been grown for a long time, inoculation with highly effective rhizobia significantly boosts productivity. For example, in southern Russia's Non-Chernozem zone, inoculation improved pea yield, increased grain protein content, and reduced soil impact due to enhanced nitrogen fixation [8]. A dissertation study in the forest-steppe of Central Black Earth Region examined the effect of seed inoculation and fertilizer application on nitrogen fixation, growth, development, yield, and seed quality of pea. Results showed that inoculation increased the number and mass of active nodules, leghaemoglobin content in nodules, and improved yield structure and seed quality [9]. These findings confirm the importance of selecting the right strain and formulation of inoculants to boost pea yield.

In addition to nitrogen-fixing bacteria, peas—like other legumes—respond positively to microbial products that improve nutrient uptake and protect against diseases. It has been noted that combining *Trichoderma* with peas promotes better plant growth and development. In one study, seed treatment with Trichoderma asperellum T42 increased overall root absorption capacity, plant biomass, and yield [10]. It is believed that *Trichoderma* improves pea nitrogen utilization (including stimulation of nitrate reductase), leading to enhanced growth, particularly under good nitrate availability [10]. Overall, integrating biopreparations into pea cultivation—such as rhizobial inoculation ("BioAzoPhosphite" equivalent for nitrogen and phosphorus) and crop protection via *Trichoderma* ("Trihoderma Fighter")—helps increase yield through improved nitrogen and phosphorus availability and reduced losses from root rot and other diseases. This is especially relevant in intensive crop rotations where peas face increased phytopathogenic pressure and often suffer from phosphorus deficiency amid declining organic matter in soils.

Current Challenges in Legume Cultivation

Despite agronomic advancements, producers of chickpea, lentil, and pea continue to face a number of serious challenges. The key contemporary issues affecting the yield and sustainability of these crops in various regions of the world are outlined below.

Global climate change is leading to an increase in extreme weather events—droughts, heatwaves, and irregular precipitation—which negatively affects legume crop yields [11]. Chickpea is traditionally considered a drought-tolerant crop, capable of withstanding hot and dry conditions better than other legumes due to its deep root system and ability to enter anabiosis under water stress. However, even chickpea suffers from extremely high temperatures during flowering and grain filling stages. It has been observed that for every 1 °C increase above the optimal temperature, chickpea yield decreases by 10–15% [12]. Modern chickpea genotypes may suffer complete yield loss (up to 100%) under extreme heat due to disrupted flowering and pod setting [13]. Similarly, combined effects of heat and drought can reduce chickpea yields by 40–50% [12]. Lentil and pea are less heat-tolerant, and high temperatures during flowering cause flower drop and a sharp reduction in pod number. Prolonged drought is especially detrimental to pea due to its relatively shallow root system—yield losses in dry regions can reach 40% or more [12]. Climate zone shifts are also causing traditional growing regions to face atypical conditions—for example, an increase in spring droughts or excessive moisture—necessitating adaptation of farming practices.

To maintain stable yields, climate adaptation measures are required: breeding of heat- and drought-resistant varieties, optimization of sowing dates (e.g., earlier chickpea sowing to avoid heat during critical growth phases), use of mulching and water-conserving techniques, and implementation of stress-protective biostimulants. In this context, the use of biofertilizers discussed earlier can play a valuable role: it is known that *Trichoderma* inoculation can enhance plant resistance to abiotic stresses and improve water and nutrient use efficiency, thereby mitigating the impact of climatic stress [14]. Thus, even highly adaptive crops like chickpea require comprehensive support—from breeding to the application of stress-protective bioformulations, including biofertilizers.

Soil Degradation and Declining Fertility

Alongside climate-related stresses, soil degradation contributes to yield instability. In Southeastern Kazakhstan, where these processes are intensifying, it is especially important to introduce crops capable of restoring soil fertility. The inclusion of legumes in crop rotations and the use of biological preparations in such conditions become not only an agronomic but also an ecological necessity.

Intensive agriculture and imbalanced fertilizer application have led to the degradation of soil resources in many regions. According to FAO estimates, about one-third of the world's soils have already degraded, posing a serious threat to food security for millions of people [15]. Depletion of organic matter, erosion, disrupted soil structure, and reduced natural fertility all negatively impact the productivity of chickpea, lentil, and pea. These crops themselves contribute to the restoration of soil fertility by fixing nitrogen and leaving behind a significant amount of residual nitrogen and organic matter. For example, chickpea can fix 25–30 kg N/ha per season, enriching the soil with nitrogen [16].

Nevertheless, on severely degraded soils, this may not be sufficient—plants may suffer from deficiencies in phosphorus, sulfur, and micronutrients, as well as from poor water-holding capacity. The degradation of chernozem and chestnut soils in arid zones reduces the yield potential of legumes, even drought-tolerant ones, due to diminished reserves of productive moisture and nutrients. Combating soil degradation requires a transition to more sustainable farming systems: the inclusion of legumes in rotations, the use of green manures, reduced or zero-tillage practices to prevent erosion, and the return of crop residues to the soil.

Biofertilizers are also part of the solution. For instance, phosphate-solubilizing bacteria can convert poorly available soil phosphorus into plant-available forms, increasing the utilization efficiency of legacy phosphorus accumulated in the soil. This is especially relevant on soils with a long history of phosphate or superphosphate application, where a significant portion of phosphorus remains locked in insoluble forms. In general, restoring soil fertility and preventing further degradation are essential conditions for the stable cultivation of chickpea, lentil, and pea in the future [17].

In this context, the development of rainfed agriculture becomes particularly significant—especially in Southeastern Kazakhstan, where limited water resources and nutrient-depleted soils demand effective and sustainable solutions. The present study is dedicated to improving legume yields under rainfed conditions using biological preparations. To achieve this, it is especially important to determine which of the available bioformulations demonstrate the highest efficiency under the specific soil and climatic conditions of the region.

Phytosanitary Threats: Diseases and Pests

Leguminous crops are susceptible to a range of harmful diseases and pests that can significantly reduce yield and product quality. In chickpea, one of the most serious diseases is fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris*), which can cause widespread plant mortality. Another major threat is ascochyta blight (caused by *Ascochyta rabiei*), a fungal disease that affects chickpea leaves and pods. Under weather conditions favorable to the pathogen (e.g., a rainy summer), ascochyta can destroy nearly the entire crop—there have been documented cases of 100% yield loss in infected fields [18]. In pea, a similar disease is caused by a complex of ascochyta pathogens (*Ascochyta pisi*, *Phoma medicaginis* var. *pinodella*, etc.) and also leads to yield loss when untreated [19]. Lentil suffers from fungal diseases such as anthracnose (*Colletotrichum lentis*), prevalent in North America, and rust (*Uromyces* spp.), common in South Asia—both of which can reduce yield by 30–50% if not managed. The spread of soil-borne phytopathogens such as *Rhizoctonia*, *Pythium*, and *Aphanomyces* leads to root rot, suppressing plant growth; in recent years, outbreaks of *Aphanomyces euteiches* in pea and lentil crops in Canada have rendered many fields temporarily unsuitable for cultivation.

Among pests, notable threats include cutworms and aphids in pea, and the chickpea pod borer (*Helicoverpa armigera*), a chickpea-specific pest whose larvae damage pods and can destroy up to 30% of the crop without insecticide protection.

Overcoming phytosanitary threats requires an integrated system of measures: breeding for resistant varieties, seed treatment (including with biopreparations), fungicide application when necessary, crop rotation, and spacing the return of crops to the same field. A promising direction is biological control—using antagonistic microorganisms. One example is *Trichoderma*—a genus on which many commercial preparations (including "Trihoderma Fighter") are based, applied to suppress soil fungal infections. *Trichoderma* competes with phytopathogens in the rhizosphere, produces enzymes and antibiotic-like compounds against pathogens, and stimulates plant immunity [20]. Studies on chickpea and other legumes show that *Trichoderma* inoculation reduces incidence of wilt and root rot and can increase yield by 25–30% compared to infected but untreated controls [21].

Bacterial preparations (e.g., "Bioprotect," containing *Pseudomonas* or *Bacillus* strains with antagonistic activity) used for seed treatment protect seedlings from fungal and bacterial infections at early development stages, increasing field germination and initial plant vigor [21]. Combining biological seed treatment with moderate use of chemical plant protection products yields the best results: in production conditions, preventive fungicide application reduced chickpea yield losses from ascochyta from ~96% to ~51% in susceptible varieties [22]. Thus, combating diseases and pests requires an integrated approach where biological methods complement traditional ones, reducing pesticide load and enhancing the ecological safety of agroecosystems.

Efficiency of Fertilizer Use

Another significant challenge is improving fertilizer use efficiency in legume cultivation systems. Although legumes can partially meet their nitrogen needs through biological fixation, achieving their full yield potential often requires supplementation with phosphorus, potassium, sulfur, and micronutrients (such as molybdenum, boron, and zinc, which are critical for nitrogen fixation and seed formation). In intensive farming systems, the problem of low fertilizer uptake efficiency is especially acute. Global statistics show that plants absorb only about 25–50% of applied nutrients, while the rest is lost from the soil through leaching, gaseous emissions, or conversion into insoluble forms [23]. Specifically, the global average nitrogen use efficiency does not exceed ~50% [24], meaning that nearly half of the applied nitrogen does not contribute to yield formation, instead escaping into the atmosphere (as N_2O, NO_X) or leaching into groundwater (as nitrates). This not only increases production costs (due to inefficient fertilizer use) but also causes environmental issues such as eutrophication of water bodies and greenhouse gas emissions.

A similar situation is observed with phosphorus: a large share of mineral phosphorus becomes unavailable to plants by binding with calcium in alkaline soils or with iron and aluminum in acidic soils. Therefore, improving the *fertilizer use efficiency* (FUE) is a crucial goal in chickpea, lentil, and pea agrotechnologies.

Addressing this issue requires both optimization of application rates and methods (e.g., localized starter phosphorus application at sowing) and the use of innovative agents that improve nutrient uptake. In this regard, biofertilizers are a promising tool. Rhizobia provide plants with fixed atmospheric nitrogen, reducing the need for mineral nitrogen. Phosphate-solubilizing bacteria (as in products like "BioAzoPhosphite") increase the share of plant-available phosphorus in the soil and fertilizers by producing organic acids and phosphatases [25].

For example, in chickpea trials, inoculation with effective phosphate-solubilizing strains such as *Lysinibacillus macrolides* and *Pseudomonas pelleroniana*, combined with moderate phosphorus doses, improved plant phosphorus uptake by ~90% compared to the control [25]. The combined use of biopreparations and fertilizers allows for reduced mineral fertilizer rates without yield loss. Moreover, microbial activity improves root development and root absorption capacity, enhancing uptake and utilization of mineral nutrients.

The use of biostimulants (such as seaweed extracts, humates, etc.) is also seen as a way to increase nutrient absorption capacity and fertilizer efficiency [23]. Ultimately, improving fertilizer use efficiency in chickpea, lentil, and pea cultivation is key to increasing yields and profitability—especially in the context of rising mineral fertilizer prices and the need to reduce agriculture's environmental footprint.

The Importance of Chickpea, Lentil, and Pea for Food Security and Sustainable Agriculture

The aforementioned crops—chickpea, lentil, and pea—hold strategic significance in the global food system and for the advancement of environmentally sustainable agrotechnologies. With their high protein content (20–25%) and essential amino acids, they serve as a primary protein source for hundreds of millions of people, especially in regions with traditionally plant-based diets. Not without reason are legumes referred to as "the meat of the poor"—they provide nutritional value comparable to animal protein at significantly lower resource costs. FAO emphasizes that promoting the cultivation and consumption of legumes addresses several key challenges at once: improving population nutrition, enhancing food security, and transitioning to more sustainable food systems [1].

Globally, chickpea and pea are among the most widely cultivated pulses (each with an annual production exceeding 14 million tons), and lentil is a staple in the diets of populations in South Asia, Africa, and the Middle East. Thus, expanding their production is directly linked to the goal of eradicating hunger and malnutrition (UN Sustainable Development Goal #2: Zero Hunger).

Beyond nutrition, leguminous crops offer agronomic benefits that make agriculture more sustainable. Their ability to fix atmospheric nitrogen through symbiosis reduces dependence on industrial nitrogen fertilizers, whose production is energy-intensive and associated with CO_2 emissions. Incorporating chickpea, lentil, or pea into crop rotations improves soil structure, enriches the soil with nitrogen for subsequent crops, and interrupts the life cycles of many cereal pests and diseases. For example, growing legumes as cover crops or in mixed sowings can enhance agroecosystem biodiversity and reduce pesticide requirements. It has also been noted that legumes improve soil water regimes and structure: their root residues and crop remains contribute to humus formation and increase soil moisture retention [1]. These effects are particularly critical in the context of land degradation and climate change.

Thus, increasing chickpea, lentil, and pea production contributes not only to food but also ecological security.

Finally, the economic importance of these crops is growing in the global food market. Demand for plant-based protein and healthy nutrition is driving legume trade: many importing countries (e.g., European nations, where chickpea-based hummus and lentil soups are popular) depend on stable supply from producers such as India, Canada, Australia, Russia, Kazakhstan, and others. Improving the yields and resilience of chickpea, lentil, and pea directly impacts the incomes of millions of farmers and the accessibility of these products for consumers. Therefore, investment in scientific research—such as the use of innovative biofertilizers and the development of new varieties—is of not only scientific but also socioeconomic importance.

Research Prospects

Southeastern Kazakhstan is characterized by rainfed (non-irrigated) agriculture, an arid climate, and soils with low humus content [26]. These conditions significantly limit crop yields due to moisture deficits and low natural soil fertility. Therefore, future research efforts are aimed at identifying resilient agrotechnologies, including the use of biofertilizers that can improve the productivity of legume crops without increasing chemical input loads on the ecosystem.

One example of such promising research is the ongoing dissertation project titled "Ecological Assessment of Soil Conditions During the Cultivation of Leguminous Crops (Chickpea, Lentil, Pea) Under Rainfed Conditions in Southeastern Kazakhstan." This study involves a comprehensive evaluation of the effects of the following factors:

- Soil types: soils from fields previously cultivated with legumes, soils from fields without prior legume cultivation, and commercially available universal soil (control substrate);
- Fertilizer types: four fertilizer variants based on Kazakhstani biological products: BioAzoPhosphite, Bioprotect, Fighter Trichoderma, and Ikar Fosfo;
- Cultivated crops: three legume species (chickpea, lentil, pea) of Kazakhstani and Canadian breeding.

The experiments are conducted under greenhouse conditions using native regional soils, allowing for the inclusion of local agroecosystem characteristics such as limited moisture and low organic matter content. The goal of the study is to develop scientifically substantiated recommendations for the application of biofertilizers to improve legume crop yields without increasing doses of mineral fertilizers and pesticides.

This research direction aligns with global trends in the development of sustainable agriculture, where biofertilizers are seen as a cost-effective and environmentally friendly tool for enhancing productivity and crop quality. The need to implement such biotechnologies to improve natural fertility and yield stability is confirmed by the fact that this issue is a focus of international scientific attention [26]. For example, in the dry steppe zone of Kazakhstan, combined application of phosphorus-containing biofertilizers and rhizobial inoculants has been shown to increase chickpea yields by 88–95% compared to the control [27]. This effect demonstrates the high potential of biofertilizers in boosting legume productivity in arid ecosystems.

Earlier, in the same region with similar soil types, field trials were conducted to assess the effect of sowing methods on the structure and yield of the “Aksary” pea variety [29].

It is worth emphasizing that the dissertation research in question is nearing completion, and specific results have not yet been published. Nevertheless, its implementation holds great practical significance for local farmers, as the expected findings will allow for optimization of biofertilizer application, increased legume yields, and preservation of soil fertility with minimal chemical input. The resulting knowledge and recommendations will make an important contribution to the development of sustainable agriculture in Kazakhstan and clearly define the prospects for further research in this field.

CONCLUSION

Chickpea, lentil, and pea are crops with enormous potential, the realization of which requires modern, science-based approaches. An analysis of existing studies shows that the use of biological products (BioAzoPhosphite, Bioprotect, Trihoderma Fighter, and similar agents) during sowing and the growing season enhances yields by improving nitrogen and phosphorus nutrition and reducing losses from diseases [11]. Integrated inoculation with rhizobia, phosphate-solubilizing bacteria, and Trichoderma fungi has proven to be an effective technique, enabling yield increases in chickpea of up to 20–30% and improving plant growth and development parameters [12]. Similar approaches have also been successfully applied to lentil and pea, increasing the efficiency of fertilizer use and stabilizing productivity even under stress conditions.

At the same time, addressing the current challenges in legume cultivation requires comprehensive measures. Climate change adaptation, soil fertility restoration, biological crop protection, and increased agrochemical efficiency must all be addressed as part of a unified system. The biologization of agriculture, based on the potential of soil microorganisms, offers a promising path toward sustainable legume production. This approach can reduce the environmental footprint of agriculture (by decreasing the use of synthetic fertilizers and pesticides) while simultaneously increasing plant-based protein output—an essential factor for the planet’s growing population.

Thus, leguminous crops are valuable not only for their nutritional content but also for their agronomic utility. The introduction of innovative bioformulations adapted to the conditions of Southeastern Kazakhstan will ensure ecologically safe and resource-efficient production. The practical significance of this research lies in the opportunity to develop recommendations for farmers and agronomists on the use of the most effective strains and inoculation schemes, potentially increasing yields under rainfed conditions without significant cost increases.

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EFFICIENT WASTEWATER TREATMENT USING PUMPKIN PEEL BIOCHAR: ADSORPTION KINETICS, PH EFFECT, AND DOSAGE OPTIMIZATION

Barkahoum Boudoumi, PhD student
Research Laboratory in Subterranean and Surface Hydraulics,
University of Biskra,
PO Box 145, Biskra, 07000, Algeria.
barkahoum.boudoumi@univ-biskra.dz

Saadia Guergazi
Research Laboratory in Subterranean and Surface Hydraulics,
University of Biskra,
PO Box 145, Biskra, 07000, Algeria.

Asma Nouioua
Research Laboratory in Subterranean and Surface Hydraulics,
University of Biskra,
PO Box 145, Biskra, 07000, Algeria.

Abstract: *The treatment of wastewater effluents is a significant challenge for environmental protection. This study investigates the use of biochar prepared from pumpkin peel as an adsorbent for treating effluent from the Ghoufi wastewater treatment plant, located in Batna, Algeria. The adsorption process was analyzed by varying key parameters, including adsorption kinetic, pH effect and biochar dosage effect. The efficiency of the treatment was assessed by monitoring chemical oxygen demand (COD), turbidity, and conductivity. Results showed that the biochar achieved removal efficiencies exceeding 86 % for each parameter after 45 min, demonstrating its potential as an effective, sustainable, and locally sourced adsorbent for wastewater treatment.*

Keywords: *wastewater effluent, adsorption, biochar, water quality, COD, turbidity, conductivity*

INTRODUCTION

The treatment of wastewater effluents is a critical component in safeguarding water quality and protecting aquatic ecosystems. Traditional treatment methods often fall short in removing certain pollutants, necessitating the exploration of alternative approaches (Wang et al., 2024). Adsorption has emerged as a promising technique for the removal of residual contaminants from wastewater (Barkahoum et al., 2025; Xiang et al., 2020).

Biochar, a carbon-rich material produced through the pyrolysis of biomass, has garnered attention for its high surface area, porosity, and functional groups, making it an effective adsorbent for various pollutants (Wu et al., 2024). In this study, biochar derived from pumpkin peel (p-biochar) was utilized to treat effluent from the Ghoufi wastewater treatment plant in Batna, Algeria. This locally sourced biochar offers an environmentally friendly and cost-effective alternative to conventional adsorbents (Özer & İmamoğlu, 2024).

The primary objective of this research was to investigate the adsorption of the effluent onto pumpkin peel biochar, considering the effects of contact time ,pH and biochar dosage. Key indicators of pollution, including chemical oxygen demand (COD), turbidity, and conductivity, were monitored to assess the treatment efficiency. The results demonstrated that p-biochar achieved removal efficiencies of 88%, 86%, and 89.1% for COD, turbidity, and conductivity, respectively, highlighting its potential as an effective adsorbent for wastewater treatment. These findings confirm the high effectiveness of p-biochar, making it a promising material for water treatment applications; however, further studies are recommended to evaluate its performance with other types of pollutants and under real-world conditions.

EXPOSITION

II. Material and method

II. 1. Adsorbent preparation (P-biochar)

Pumpkin peels were used as biomass for biochar production. The peels were first washed, cut into small pieces, and air-dried. Pyrolysis was then carried out in a muffle furnace under limited oxygen conditions. The resulting sample underwent acid washing to remove impurities, followed by thorough rinsing with distilled water until a neutral pH was reached. Finally, the material was dried and stored for subsequent use. The overall preparation steps are illustrated in Fig.1, and the detailed preparation protocol can be found in a previous study (Barkahoum et al., 2025).

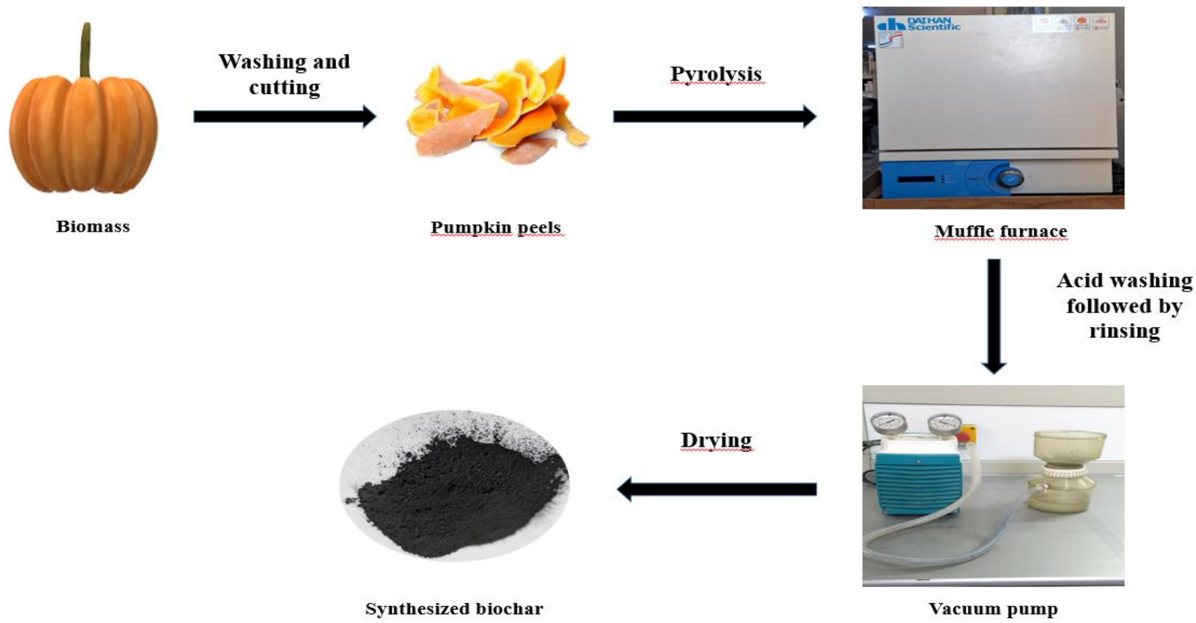

Fig. 1. Schematic representation of the preparation process of pumpkin peel-derived biochar

II. 2. Wastewater treatment plant effluent (WWTP effluent)

The effluent used in this study was collected from the wastewater treatment plant located in Batna, Algeria. The sampling was carried out after the preliminary treatment steps. At this stage, the effluent had not yet undergone any biological or chemical treatment. The main physicochemical parameters of the collected effluent are summarized in Table 1.

Table. 1 physicochemical parameters of the collected effluent

Parameter	Unit	Value
pH	/	7.28
COD	mgO_2/L	600
Turbidity	NTU	120
Conductivity	ms/cm	1900

II. 3. Experimental protocol

Adsorption experiments using pumpkin-based biochar were conducted on real wastewater collected from a treatment plant. Each test was performed in a 100 mL flask containing 50 mL of wastewater and 0.5 g/L of biochar, under magnetic stirring. After agitation, the mixtures were filtered using a vacuum pump and microporous filters. Water quality after treatment was monitored by measuring Chemical Oxygen Demand (COD), turbidity, and electrical conductivity. Defirent parametres were varied to determine the optimal conditions of the process, such as;

Adsorption kinetic: to identify the time needed to reach equilibrium.

pH effect: to assess its influence on adsorption efficiency. Knowing that, the pH of the effluent was adjusted using HCl and/or NaOH as needed.

Adsorbent dose effect: to evaluate the effect of adsorbent quantity on removal performance.

The removal efficiency of each parameter was calculated using the following equation:

$$\text{Removal efficiency (\%)} = \frac{C_i(\text{X})-C_f(\text{X})}{C_i(\text{X})}\,100 \qquad (1)$$

Where, C_i (X) and C_f (X) are the initial and final concentration of X parameter, respectively.

III. Results and discussion

III. 1. Adsorption kinetic

Fig. 2 illustrates the adsorption kinetics of a real wastewater effluent treated with p-biochar, tracking three key water quality parameters: COD, turbidity and conductivity. A rapid decrease in all three parameters is observed during the initial contact period, particularly within the first 30 minutes. This indicates a high availability of active sites on the biochar surface at the beginning of the process. Turbidity and conductivity reached near-equilibrium quickly, showing minimal variation beyond 45 minutes, suggesting that physical and ionic interactions responsible for their removal occur rapidly. In contrast, COD removal continues to increase slightly before stabilizing, indicating that the degradation or adsorption of organic matter is a relatively slower process compared to the removal of suspended solids or dissolved ions. Overall, equilibrium was approximately reached after 45 minutes, with COD reduced to 72 mgO_2/L, turbidity to 16.8 NTU, and conductivity to 207 ms/cm.

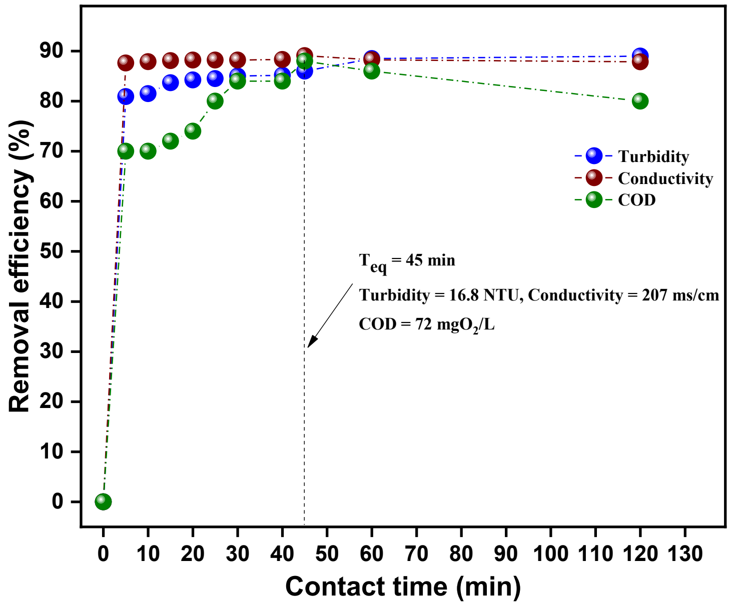

Fig. 2. COD, turbidity and conductivity variation as function of contact time.

III. 2. pH effect

The graph presented in Fig. 3 illustrates the impact of pH (ranging from 2 to 12) on the removal efficiency of COD, turbidity and conductivity in wastewater with an initial pH of 7.28. The efficiency is lowest under strongly acidic and alkaline conditions, while maximum removal (90 %, 98 % and 89.1 % for COD, turbidity and concuctivity, respectively) occurs near neutral to slightly alkaline pH values (around 7–8). This indicates that p-biochar exhibits pH-dependent adsorption behavior, with optimal performance near the natural pH of the wastewater. These findings are in agreement with those reported by Barad et al (Barad et al.). The reduced efficiency at extreme pH levels may be attributed to alterations in surface charge, functional group ionization, or pollutant speciation.

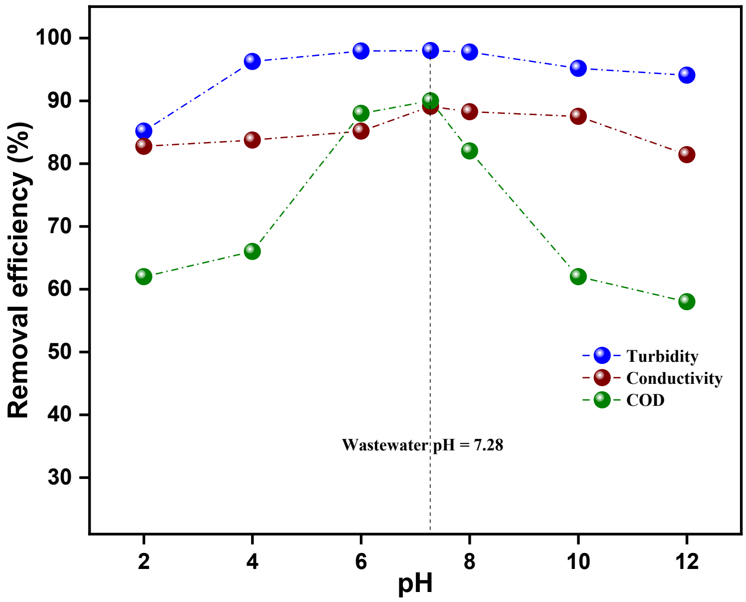

Fig. 3. Effluent pH effect on adsorption process

III. 3. Adsorbent dose effect

Fig. 4 illustrates the relationship between p-biochar dose (0.1–3 g/L) and the removal efficiency of COD, turbidity, and conductivity. As the dose increases from 0.1 to 1 g/L, removal efficiency rises significantly, reaching maximum values of 94% for COD, 98% for turbidity, and 89.5% for conductivity at 1 g/L. Beyond this optimal dose, additional increases do not result in substantial improvements, likely due to the saturation of active sites, adsorption equilibrium, or particle aggregation. Therefore, 1 g/L is considered the most effective and economical dose, as it ensures high pollutant removal without unnecessary material use. This behavior aligns with typical adsorption dynamics, where efficiency plateaus once maximum capacity is reached (Liang et al., 2021).

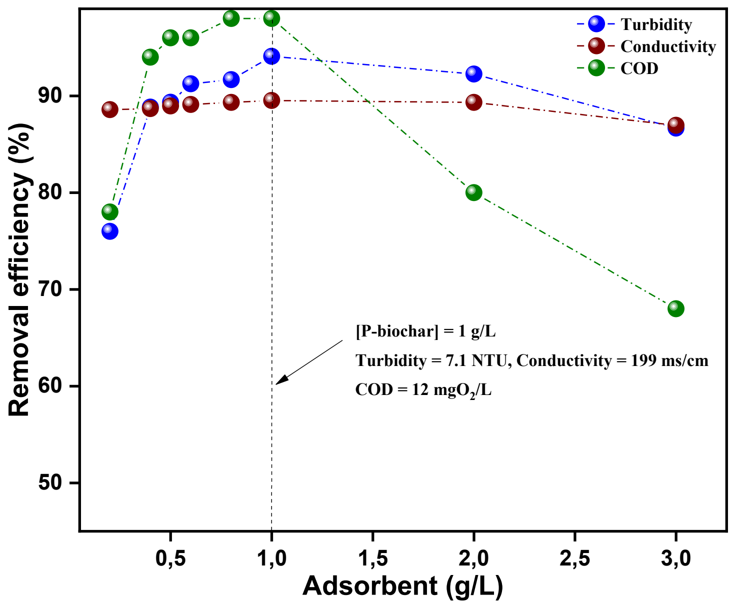

Fig. 4. Variation of COD, turbidity and conductivity as function of the variation of p-biochar

CONCLUSION

The use of pumpkin peel biochar has proven to be an effective method for treating wastewater effluent from a treatment plant in Ghoufi, Batna, Algeria. By examining various parameters, including adsorption kinetics, pH effects, and biochar dosage, significant removal of pollutants was observed, particularly in terms of COD, turbidity, and conductivity. With removal efficiencies of 88 %, 86 % and 89.1 % for COD, turbidity and conductivity, the study highlights the potential of p-biochar as a viable and sustainable alternative to commercial adsorbents. This research underscores the effectiveness of locally sourced, natural, and eco-friendly solutions in improving wastewater treatment processes, with potential applications for larger-scale use in similar regions.

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CONTEMPORARY TRENDS IN SUSTAINABLE INTERIOR SOLUTIONS[2]

Lora Stefanova, PhD Student
Department of Industrial Design,
University of Ruse "Angel Kanchev"
Tel.: +359 98 876 5005
E-mail: lstefanova@uni-ruse.bg

Assoc. Prof. Yordan Doychinov, PhD
Department of Industrial Design,
"Angel Kanchev" Univesity of Ruse
Phone: +359 88 727 3040
E-mail: doichinov@uni-ruse.bg

Abstract: *Environmentally responsible or so-called sustainable design is a fundamental topic at the moment – both in construction and interior architecture, and in all other spheres of life. At the same time, the application of environmental criteria and techniques in the practice of interior design continues to be neglected, especially when choosing ecological materials. We are witnessing a large-scale development in the construction industry, but recent scientific studies prove what we see with the naked eye – the unconscious and unregulated choice of materials together with the lack of standards lead to serious harm to people and the environment.*

It is time for Bulgaria to become part of the global trend of sustainable interior solutions. Along with the high quality of the materials and the ecological and economic benefits, this approach is also of significant importance for human health. The need for conscious choice – avoiding toxic and difficult-to-recycle materials in favor of natural, biodegradable and sparing resources – is proven by more and more studies.

Keywords: *Design, Sustainable interior solutions.*

ВЪВЕДЕНИЕ

Екологично отговорният или т.нар. устойчив дизайн е фундаментална тема в момента - както в строителството и вътрешната архитектура, така и във всички други сфери на живота. Същевременно продължава да се пренебрегва прилагането на критерии и техники за екологичност в практиката на интериорното изграждане, особено при избора на екологични материали. Свидетели сме на мащабно развитие в строителната индустрия, но последните научни изследвания доказват това, което виждаме и с просто око – несъзнателният и нерегулиран избор на материали наред с липсата на стандарти водят до сериозни здравословни вреди за хората и околната среда.

Лошият навик и инерцията да чакаме напреднали икономически държави да ни показват пътя към по-екологични индустрии трябва да се промени. Време е България да стане част от световната тенденция на устойчивите интериорни решения. Наред с високото качество на материалите и екологичните и икономически ползи, този подход има съществено значение и за човешкото здраве. Нуждата от съзнателен избор – избягването на токсични и трудно рециклируеми материали в полза на естествени, биоразградими и щадящи ресурси се доказва от все повече изследвания.

ИЗЛОЖЕНИЕ

Устойчив дизайн: минало и настояще

В миналото строителството е тясно свързано с използването на местни, натурални материали, добивани основно от заобикалящата ни природна среда. По естествен начин хората са използвали заобикалящата ги флора, фауна и наличните, достъпни ресурси.

[2] Докладът е представен на студентската научна сесия на АИФ на 08.05.2025 г. с оригинално заглавие на български език: СЪВРЕМЕННИ ТЕНДЕНЦИИ В УСТОЙЧИВИТЕ ИНТЕРИОРНИ РЕШЕНИЯ.

Днес в съвременното строителство много от хилядолетните практики в архитектурата и интериорното изграждане се разглеждат като екологично устойчиви. Повечето отново включват използване на естествените материали, които се намират в съответната географска зона и природен хабитат. В древната българска архитектура ***камъкът*** и ***тухлата*** са основни строителни материали, предпочитани заради своята издръжливост. Те са използвани за изграждане на църкви, манастири и крепости. В традиционните селски къщи пък ***дървото*** и ***плетовете*** са по-голямата част от конструкциите, а ***глината***, ***кирпичът*** и ***варта*** са служели за вътрешно и външно измазване. Традиционните строителни техники като ***трамбоване на земя*** и ***редене на каменни плочници*** са популярни в различни региони на България.

Фиг. 1. Традиционна българска къща. Източник: https://unsplash.com/photos/brown-wooden-house-near-trees-during-daytime-tYhmb2YXQZU

Постройките и домовете са били съобразени с околната среда чрез разположението си върху, под или в земя и скала и ориентацията си спрямо слънцето и спрямо водоизточниците в близост.

Тези практики днес са вдъхновение в световните тенденции на съвременното екологично строителство и интериор, стремящи се към естетика, устойчивост, здравословност и връзка с природата.

Съчетание на естетическите и функционални аспекти на дизайна с екологичната отговорност

Екологично устойчивият дизайн („design“ – в превод от англ. ез. дизайн, проект, конструкция, оформление, замисъл, устройство) е концепция, която е фокусирана върху създаването на продукти, сгради и системи, които минимизират негативното въздействие върху околната среда и оптимизират ефективното използване на ресурсите. Целта са дълготрайни, екологосъобразни и естетически решения, които да ни предоставят по-здравословен и хомогенен с природата живот.

Видове устойчиви материали за строителство

Характерно за устойчивите сгради е, че подходът е насочен към материалите, вода, земя и енергия. Стремежът в момента е всичко това да се използва по-ефективно в масовото строителство. Но вътрешните пространства на зелените сгради трябва преди всичко да осигуряват здравословна, комфортна и продуктивна за обитаващите среда. А това включва и всички конструктивни елементи на интериора – вътрешни и преградни стени, подове и подови настилки, тавани, вътрешна изолация, мазилки, интериорни бои и др.

Фиг. 2. Колаж на авторите. Източник на снимки: ***Sevarex*** и ***Pinterest***.

Въглеродно неутралните конструкции и материали, налични в момента на световния пазар, са следните категории:

- Материали на земна основа, където попадат: “Earthbags” – напълнени с локална почва конопени чували за изграждане на стени и конструкции, кирпичени тухли (Adobe); компресирани земни блокове (CEBs); глинени плочи; глинени и варови мазилки и др.;
- Композитни материали на растителна основа – такъв е линолеумът, който най-често се бърка с балатум и винил-подовите настилки. Той е напълно естествен и 100% биоразградим. Прави се от ленено масло, борова смола, корк, дърво, различни пигменти и варовик. Благодарение на състава си, той е антистатичен, антиалергичен и

антибактериален материал. По време на производството му и използването му няма поява на токсини вредни за човека и средата, даже е и полезен за хора с дихателни проблеми, поради изпаренията на боровата смола. Друг пример за композитни материали са палмовото дърво, който е страничен продукт от палмово масло или фурми. Хартиеният бетон, който е лек композит от рециклирана хартия, вода и цимент. Също така биопластмасите, които се извличат от царевично нишесте или захарна тръстика;

- Материали с метална и минерална основа – рециклираният алуминий, естественият камък, като гранит или шисти с местен произход, глинените плочки и керемиди, гипсокартонът – екологично устойчив при рециклиране или отговорен източник на гипс;
- Рециклирани и регенерирани материали – рециклирана дървесина от съборени сгради, стомана с по-нисък въглероден отпечатък, както и пластмаса и стъкло, използвани за настилки, облицовки и плотове. Сред алтернативите са още възстановени тухли, рециклиран каучук за подови и покривни настилки, бетон от летлива пепел (от въглища) и килимни плочки, произведени от отпадъчни текстили;
- Иновативни и алтернативни материали – газобетон и геополимерен бетон с по-нисък въглероден отпечатък, CLT (кръстосано ламинирано дърво) и SIP панели с висока топлоизолация. Сред новите решения са прозрачното дърво (алтернатива на стъклото), рециклираният асфалт и Ferrock – бетон, който абсорбира въглерод, направен от стоманен прах.

Естествени изолации срещу шумовото замърсяване

Постоянният градски шум, както и строителните и ремонтни дейности оказват значително негативно влияние върху качеството на живот. Свързваме чистотата на околната среда основно с качеството на въздуха, качеството на живот и нивата на комфорт, но те зависят изключително и от акустичните свойства на материалите, използвани в строителството и в интериорното изграждане – независимо дали си даваме сметка за това или не.

Естествени материали с добри акустични свойства

Естествените материали проявяват разнообразни акустични свойства, което ги прави ценни и за приложения като звукопоглъщане и изолация. Натуралните влакна като коноп, лен, юта, кокосови влакна, капок и влакна от листа от ананас имат обещаващи възможности за звукопоглъщане. Проучванията показват, че тези растителни влакна са на нивото на конвенционалните материали като стъклени влакна, особено в средночестотния диапазон (500–2000 Hz) – критичен за човешкия слух. Ключови фактори, влияещи върху техните акустични характеристики, включват:

- Порьозност и структура на влакната – порестата природа и сложните структури на влакната подобряват звукопоглъщането чрез улавяне на звукови вълни;
- Съпротивление на въздушния поток – това определя колко лесно въздухът (и следователно звукът) преминава през материала; оптималното съпротивление подобрява поглъщането;
- Дебелина и плътност – при материалите, получени от естествени фибри и влакна, лесно се постига баланс между лекотата и ефективността на материала.

Мицелът, кореноподобната структура на гъбите, се очертава като устойчив акустичен материал. Панелите, изработени от мицел, показват звукопоглъщащи свойства, сравними с традиционните материали като пяна и корк, особено при честоти над 3000 Hz. Въпреки това, тяхното представяне при по-ниски честоти е по-малко ефективно.

Други естествени материали като корк, овча вълна и кокосови влакна също притежават забележителни акустични свойства. Клетъчната структура на корка осигурява добра звукоизолация и поглъщане.

При овчата вълна пък естествено накъдрените влакна улавят въздуха, подобрявайки звукопоглъщането в диапазон от честоти. Кокосовите влакна са твърди и груби, предлагайки издръжливост и прилични акустични характеристики.

Фиг. 3. Видове коркови изолации. Източник: https://cork-bg.com/

Поради тяхната биоразградимост, ниска плътност и ефективно звукопоглъщане, в някои държави естествените материали се използват все по-често в шумоизолация на сгради (за стени, тавани и подове). В студиа, зали за аудитории и офиси различни акустични панели от био материали се използват за подобряване на качеството на звука. Напоследък те се използват вече и в автомобилната индустрия за намаляване на шума в интериора на купетата.

Състояние на зелените сгради и устойчиви материали в България

Съществуващите жилищни сгради в България често имат ниска изолационна способност. Това влошава комфорта на обитателите и води до високо потребление и сметки за енергия за отопление и охлаждане. Когато тази енергия идва от изкопаеми горива, въглеродният отпечатък нараства – проблем, който засяга всички ни.

Строителството и архитектурата в България са се променяли непрекъснато в различните епохи и политикономически условия. Факт е, че „зелени” сгради вече се строят и у нас.

Вече има компании, които предлагат изцяло екологични и устойчиви интериорни материали с богат набор от изолационни панели, естествени вати, екологични бои, мазилки и лепила с напълно натурален произход. Сред артикулите им присъстват и различни екологични тапети от юта, както черги и одеала, произведени в България. На българския пазар вече има продукти като килими и мокети от кашмир в категорията екологичен дизайн, произведени в Германия.

В концепцията на устойчивия дизайн и на нарастващата нужда от зелено строителство и екологичен интериор е редно да си зададем следните въпроси:

- По какви критерии да избираме интериорните и строителни материали за дома ни, офиса, обществените зали и помещения?
- Колко и какви от изброените в класификацията строителни и интериорни материали можем и би било удачно да произвеждаме самите ние в България?

- Какво имаме и какво можем да си набавим като ресурси?
- Кои са най-добрите предпоставки и най-сериозните предизвикателства за евентуални местни производства?

BREEAM: Стандарт за устойчивост и здравословна среда в интериорния дизайн

Стандартът BREEAM отговаря за най-добрите практики в устойчивия дизайн и се превръща в мярка за екологичните показатели на обектите. В системата му за оценяване влизат управление на енергията, транспорт, качество на водата, отпадъци и др. Голям процент от критериите за оценяване има именно категорията на материалите - с тежест от 14%. В тях се разглеждат влиянието на жизнения цикъл на всеки строителен материал, включително и начина на добиване на суровината. Следват производството, транспорта и монтажа, евентуалните поправки и окончателните мерки за отстраняването, повторната употреба и унищожаването на съответния материал и продукт. Вземат се предвид и отговорният принцип при доставката на материалите, изолацията и проектирането.

Влияние върху човешкото здраве на най-използваните в интериора материали

Строителството и разрушаването на сгради произвеждат огромни количества отпадъци, включително бетон, тухли, метал и пластмаси, а те много често не се рециклират. Редица от тези отпадъци съдържат опасни химикали, които замърсяват почвата и водите. Производството на материали като цимент (основна съставка на бетона) генерира значителни количества въглероден диоксид. Изследвания сочат, че производството на цимент е отговорно за близо 7% от глобалните емисии. Възникващ въпрос тук е - има ли как да се използва по-малко бетон в сградостроенето за сметка на алтернативни решения в преградни и вътрешни стени например?

Някои широко използвани интериорни материали могат да имат негативно въздействие върху човешкото здраве поради съдържащите се в тях химически вещества и емисии. Формалдехидът, например, който се използва в производството на дървесни плоскости като ПДЧ и МДФ, както и в някои лепила и покрития, може да се разпространява във въздуха в помещенията и да предизвика дразнене на очите, носа и гърлото, както и алергични реакции. Дългосрочното излагане на формалдехид е свързано с повишен риск от развитие на респираторни заболявания и дори някои видове рак.

Друг широко използван материал е стиропорът (експандиран полистирол), който се използва като изолационен материал. Основната му съставка, стиренът, е токсично вещество, което при високи концентрации може да причини заболявания на кръвта и нарушения на нервната система. Въпреки че концентрациите в готовите продукти обикновено са ниски, стиренът има способността да се натрупва в организма чрез вдишване, което може да доведе до здравословни проблеми при продължително излагане.

Способността да пропускат пара е важно качество за изолационните материали, но полистироловите листове практически нямат такава. Това в много случаи води до лош обмен на въздух, мухъл и плесен по стените и се увеличава рискът от развитие на патологии на дихателната система, мигрена, лошо храносмилане или дисфункция на вътрешните органи. По отношение на запалимостта този продукт се счита за най-опасен и има категория G3-G4. Поради това, че е лек, но обемист (а това увеличава разходите, за неговата доставка, а после и транспорт за извозване до сметищата) стиропорът практически не се рециклира.

Безспорната истина е, че е по-евтино и по-лесно да се произвежда нов полистирол, отколкото да се събира, транспортира и използва повторно, поради което много фирми и съоръжения за рециклиране нямат никаква изгода от това. Така често се налага изгарянето на отпадъците от такъв тип, което само по-себе си е екологична катастрофа. Когато се гори при по-ниски температури (лагерен огън или домашна камина), полистиролът може също да произвежда ПАВ (полицикличен ароматен въглеводород), както и канцерогенни стиренови мономери и смъртоносен въглероден оксид. Изследванията са категорични – материалите от този тип са канцерогенни.

Фиг. 4. Отпадъци от стиропор. Източник: https://builderhuben.techinfus.com/penoplast/varianty-dekora/

Много бои, лакове и покрития съдържат летливи органични съединения (ЛОС), които се изпаряват във въздуха и могат да предизвикат дразнене на дихателните пътища, главоболие и замайване. Дългосрочното излагане на ЛОС е свързано с хронични здравословни проблеми, включително увреждане на черния дроб и бъбреците.

Лошата вентилация и високата влажност в помещенията, образуването на плесени и мухъл, които освобождават спори във въздуха са чести причини за алергични реакции, астма и други респираторни проблеми, особено за децата в най-ранна възраст.

ЗАКЛЮЧЕНИЕ

Предстоят ни важни и решаващи крачки – не само към по-устойчив начин на живот, но и към дълбока промяна в разбирането за това какво означава отговорен дизайн. Предлагането на устойчиви интериорни решения в България е логично завръщане към традиционните строителни и интериорни практики, но и крайно необходимо – както за опазване на околната среда, така и за съхраняване на човешкото здраве. Това означава на практика преминаване от токсични и нерециклируеми материали и съзнателно насочване към естествени, биоразградими и местни ресурси. Време е да мислим не само за естетичното и красивото, но и за отговорното и здравословното – с визия, която пази нас и планетата.

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