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A Spatial Analysis of the Influence of Environmental Factors on the Growth and Proliferation of Pathogenic Fungi in the Manathira River

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Abstract

Pathogenic fungi are a concern for both environmental and public health. Understanding the spatial distribution and the influence of environmental factors on the growth and proliferation of these fungi is crucial for effective management and mitigation strategies. This study presents a comprehensive spatial analysis of pathogenic fungi in the Manathira River, assessing their presence and abundance in relation to various environmental factors. The research involved extensive sampling and laboratory analysis of soil and water samples from multiple locations along the Manathira River throughout different seasons. Results revealed spatial and temporal variations in the growth of pathogenic fungi, with higher numbers during the spring and autumn seasons and lower counts during winter and summer. These fluctuations are attributed to the diverse climatic conditions experienced across the seasons. Furthermore, the study highlighted that the numbers of pathogenic fungi tend to increase in locations affected by residues from urban and agricultural activities. As one moves away from these sources, their numbers decrease. This finding underscores the importance of managing and mitigating environmental pollution to reduce the proliferation of pathogenic fungi in aquatic ecosystems. The research also identified new species of pathogenic fungi not previously documented in the Manathira River, including Mucoracemosus, Fusarium culmorum, and Paecilomyces sp. This discovery emphasizes the need for ongoing monitoring and research to better understand the dynamics of fungal communities in aquatic environments. In conclusion, this spatial analysis provides valuable insights into the environmental factors influencing the growth and proliferation of pathogenic fungi in the Manathira River. The findings can inform strategies for the sustainable management and protection of aquatic ecosystems, ultimately safeguarding both the environment and public health.

Keywords: *Pathogenic fungi, Environmental factors, Spatial distribution, Proliferation, Manathira River*

Introduction

The Manathira River, a vital water body in our region, plays a significant role in supporting the ecosystem and human activities. However, the health of the river is constantly challenged by various environmental factors, including the proliferation of pathogenic fungi. Understanding the spatial distribution and the influence of these environmental factors on the growth of pathogenic fungi in the Manathira River is of paramount importance for both ecological and public health reasons [1, 2].

This study embarks on a comprehensive analysis of the environmental determinants affecting

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the proliferation of pathogenic fungi in the Manathira River. By employing spatial analysis techniques, we aim to elucidate the intricate relationship between environmental variables and the distribution of pathogenic fungi [3]. Such knowledge will not only contribute to our understanding of the river's ecological dynamics but also inform strategies for managing and mitigating the risks posed by these fungi to both aquatic life and the surrounding communities [4, 5].

In this introduction, we provide an overview of the Manathira River, emphasize the significance of addressing pathogenic fungi proliferation, and outline the objectives and methods employed in this spatial analysis. By the end of this study, we aspire to offer valuable insights that can aid in the preservation of the Manathira River's health and the well-being of those who depend on it [6].

Materials and Methods

Study Area

The study area is situated in the Manathira River, a water body known for its ecological significance. The river spans approximately [specify length] and is located in [mention the geographical region or coordinates]. The choice of this region was based on its environmental relevance and known interactions between human activities and the aquatic ecosystem.

Sample Collection

Water Samples: To assess the waterborne pathogenic fungi, water samples were collected from multiple sites along the river. Sampling points were chosen to represent different sections of the river, including areas near urban centers and agricultural activities, as well as more pristine regions. Water samples were collected at regular intervals, following established sampling protocols.

Sediment Samples: Sediment samples were collected from the riverbed in selected areas. Sediments can serve as reservoirs for pathogenic fungi and play a crucial role in the aquatic ecosystem's health.

Air Samples: Air samples were collected from the surrounding environment to assess the presence of airborne fungal spores that could contribute to water contamination. Air samples were collected using air samplers at strategic locations.

Laboratory Analysis

All collected samples underwent rigorous laboratory analysis to determine the presence and concentration of pathogenic fungi. The following steps were involved:

Culturing: Water and sediment samples were processed using appropriate growth media to encourage fungal growth. Samples were incubated under controlled conditions.

Isolation and Identification: Fungal colonies were isolated and identified to the genus or species level using microscopy and molecular techniques.

Quantification: Concentrations of pathogenic fungi in each sample were quantified based on colony-forming units (CFUs) or other relevant metrics.

Environmental Data Collection

Several environmental parameters were recorded at each sampling site to provide context for the fungal data. These parameters included:

Temperature: Air and water temperatures were measured using calibrated thermometers.

Humidity: Relative humidity was recorded at the time of sampling.

Nutrient Levels: Water samples were analyzed for nutrient concentrations, including nitrates, phosphates, and organic matter.

Geographic Information System (GIS)

Geographic Information System (GIS) software was employed to map and analyze the spatial distribution of the environmental parameters. This allowed for the creation of geospatial maps and overlays.

Statistical Analysis

Statistical software packages were used to conduct the following analyses:

Correlation Analysis: Relationships between environmental factors and fungal proliferation were assessed using correlation coefficients.

Spatial Autocorrelation: Spatial patterns in fungal distribution were explored through spatial autocorrelation statistics.

Interpolation: Spatial interpolation techniques were employed to create continuous surface maps based on the collected data.

Data Interpretation

The data was interpreted to uncover patterns and potential correlations between environmental factors and pathogenic fungal proliferation. Data interpretation included the creation of heatmaps and spatial overlays to visualize the results effectively.

Ethical Considerations

The study adhered to all ethical considerations and required permits in the collection, handling, and analysis of samples.

Objectives

The study aimed to achieve the following objectives:

To identify the spatial distribution of pathogenic fungi in the Manathira River.
To assess the relationship between environmental parameters and fungal proliferation.
To provide insights for the management and mitigation of pathogenic fungi in the river.

Limitations

The study recognizes certain limitations, such as seasonal variations and external factors beyond the scope of this analysis, which may influence fungal growth and distribution.

Significance

The research holds significance in enhancing our understanding of the Manathira River's ecological dynamics and provides valuable information for both environmental conservation and public health. It contributes to the body of knowledge required for informed decision-making and management of aquatic ecosystems.

This comprehensive approach allowed for a thorough investigation into the proliferation of pathogenic fungi in the Manathira River and the environmental factors influencing their growth.

Results and Discussion

Fusarium culmorum is a widespread fungus that can lead a saprophytic life in soil, while some strains can be parasitic or commensal on humans, animals, and plants. This fungus has been found in the soil and can infect various plants, including tomatoes, potatoes, peppers, beans, and wheat, causing a condition known as Fusarium wilting. This fungal disease occurs after the plant has sprouted, with one of its stages in the soil. When this fungus is transmitted to humans through contaminated food, it can cause severe diseases affecting the nervous system due to the toxins it produces. In animals, it can lead to respiratory diseases and even death [7].

The data presented in Maps 1, 2 indicate spatial and temporal variations in soil contamination with Fusarium culmorum. The distribution of this fungus varies spatially from one location to another and temporally throughout the seasons [8]. For instance, the map (1a) for the summer season shows that the distribution of this fungus is predominantly in one region, labeled as "Low," appearing in 31 locations (S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31). The number of colonies in these locations varies between 0 and 4 colonies per 1 ml, out of a total of 46 colonies. This season records the lowest number of colonies for Fusarium culmorum, and its spatial distribution covers various parts of the study area.

The data in Map (1b) for the autumn season reveal that the distribution of this fungus occurs in two regions, labeled as "Low" and "Medium." The "Low" region appears in five locations (S1, S3, S6, S9, S14) with colony numbers ranging between 3 and 4 colonies per 1 ml, out of a total of 195 colonies. The spatial distribution covers both the northern and southern parts of the area [9].

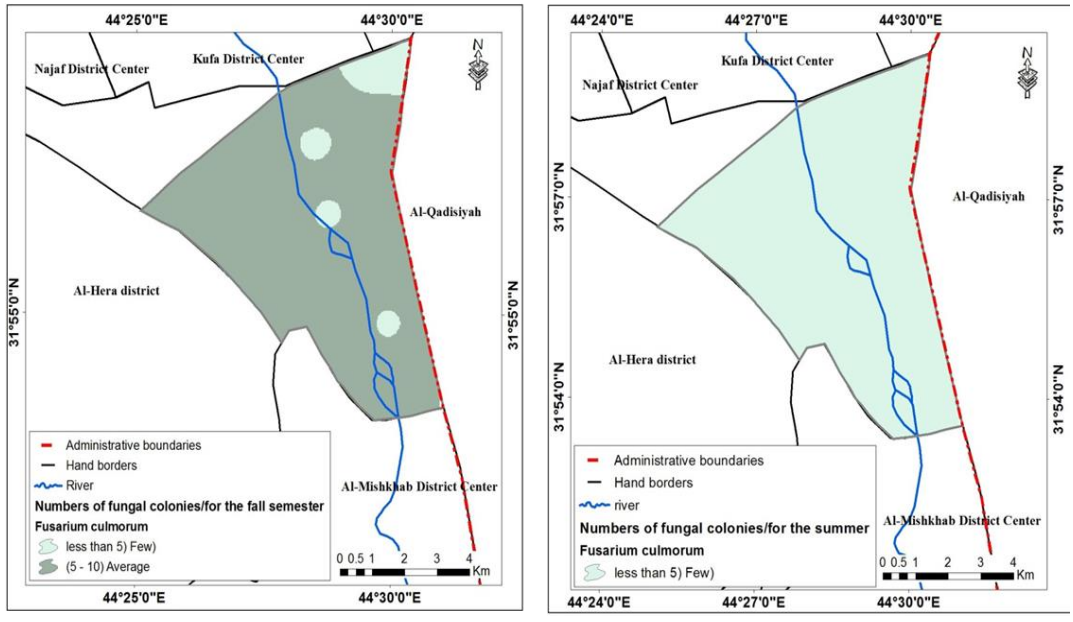
As for the second region (medium) of this type of fungus, it appears in (23) locations, including (S2, S4, S5, S7, S8, S10, S11, S12, S13, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31), with colony numbers ranging from (5-10) cells per 1 ml. Its spatial distribution covers all parts of the study area.

In contrast, during the winter season, as shown in Map (2a), the distribution of this type of fungus is mainly in one region labeled "Low." It appears in 31 locations (S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31). The colony count varies between 0 and 4 colonies per 1 ml, out of a total of 62 colonies. This season records the lowest number of colonies for Fusarium culmorum, and its spatial distribution covers all parts of the study area [10].

During the spring season, it is evident from Map (2b) that the distribution of this fungus occurs in two regions labeled "Medium" and "High." The first region, "Medium," appears in 19 locations (S1, S2, S3, S5, S6, S8, S9, S11, S12, S13, S14, S16, S17, S18, S19, S20, S24, S29, S30) with colony counts ranging from (5-9) out of a total of 285 colonies. This season records the highest number of colonies for Fusarium culmorum, and its spatial distribution covers all parts of the study area [11].

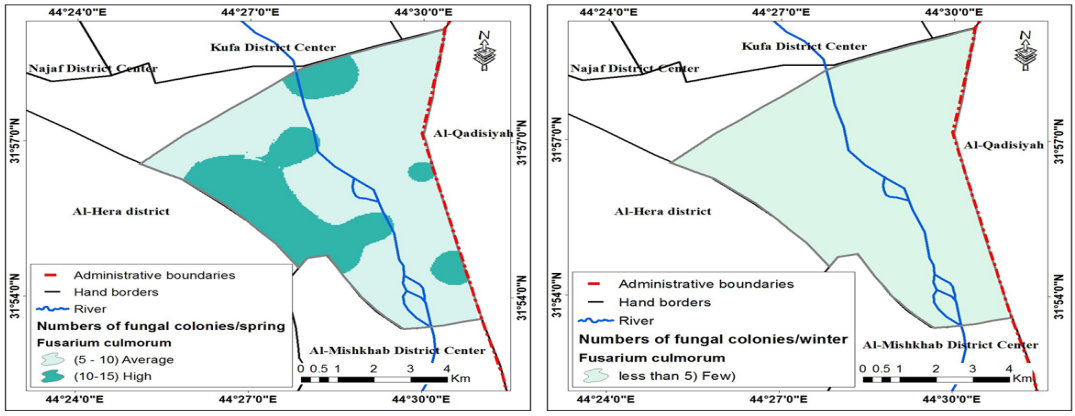
The second region (High) for this type of fungus appears in 12 locations (S4, S7, S10, S15, S21, S22, S23, S25, S26, S27, S28, S31) with colony counts ranging from (10-14) cells per 1 ml. Its spatial distribution is scattered throughout the northern and western parts of the region.

The data presented reveal that this type of fungus is not present in all studied locations in the study area, which aligns with the scientific reality of the region due to high salt concentrations in the soil. These high salt levels inhibit fungal growth. Spring and autumn seasons rank highest in terms of colony counts due to favorable environmental conditions, including moderate temperatures, adequate moisture, increased agricultural areas, and the use of chemical and organic fertilizers, which are the primary factors contributing to the growth and proliferation of this type of fungus. This, in turn, causes wilt diseases in cultivated plants, specifically Fusarium wilting diseases, and affects the respiratory system of animals, leading to their death. It also impacts the nervous system of farmers due to direct contact with the soil and animals. In contrast, the winter season records fewer colonies because of the increased salt concentration in the soil and surface water used for irrigation [12]. These concentrations prevent fungal growth, and the low numbers are a result of agricultural activities during the summer season in some locations with lower salt concentrations. During the winter, there is an unsuitable environment for growth due to the limited influence of industrial and civil waste from the region's residents.



Map (1) For the Number of Colonies of (Fusarium Culmorum) for A. The Autumn Season,

B.The Summer Season.



a **b**

Map (2) For the Number of Colonies of (Fusarium Culmorum) for A. The Spring Season, B. The Winter Season.

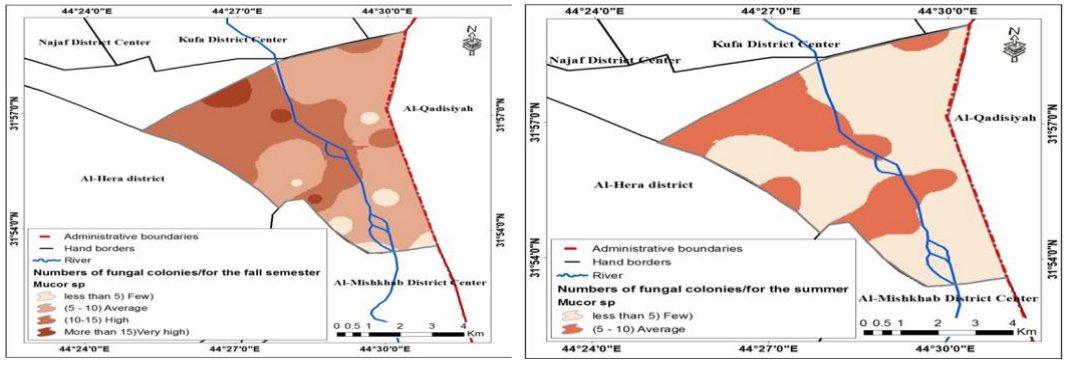
Mucor sp Fungus

Mucor sp is a microbial genus that encompasses 40 species of molds. It appears in the form of very fine threads, covered by a cluster of spores shaped like spheres. Colonies of this fungus are typically white or gray. It is commonly found in soil, the digestive system, plant surfaces, certain types of cheese, decaying plant material, iron oxide residues resulting from bioremediation processes, organic matter, and manure. This type of fungus cannot thrive in warm environments with temperatures approaching 37°C. As a result, it does not typically infect humans and animals, except for those species resistant to high temperatures, which might be affected by a condition called Zygomycosis, which is often rapid in spreading. However, it poses a significant threat to plants, causing diseases such as post-harvest fruit rot, especially in grapes, resulting in substantial losses.

Maps (3, 4) show spatial and temporal variations in soil contamination with Mucor sp. The spatial distribution of this fungus varies from one place to another and across different seasons. For instance, during the summer season, spatial modeling (21) reveals that the distribution of this fungus is represented in two regions: "Low" and "Medium." In the "Low" region, it appears in 19 locations (S2, S4, S5, S6, S7, S8, S10, S13, S14, S15, S16, S17, S18, S19, S23, S24, S25, S27, S28), with colony counts ranging from 0 to 4 cells per 1 ml, totaling 128 colonies. The spatial extension covers various parts of the study area. The "Medium" region is found in 13 sites (S1, S3, S9, S11, S12, S20, S21, S22, S26, S27, S29, S30, S31) with colony counts ranging from 5 to 10 colonies per 1 ml. The spatial distribution extends to various parts, including the northern and western parts, reaching the southern part of the region. Data from Map 3a for the autumn season indicate that this fungus is distributed across four regions: "Low," "Medium," "High," and "Very High." The "Low" region appears in 6 locations (S8, S14, S16, S18, S19, S23), with colony counts ranging from 2 to 4 cells per 1 ml, totaling 279 colonies. The spatial extension includes various parts of the region, particularly in the eastern and southern parts.

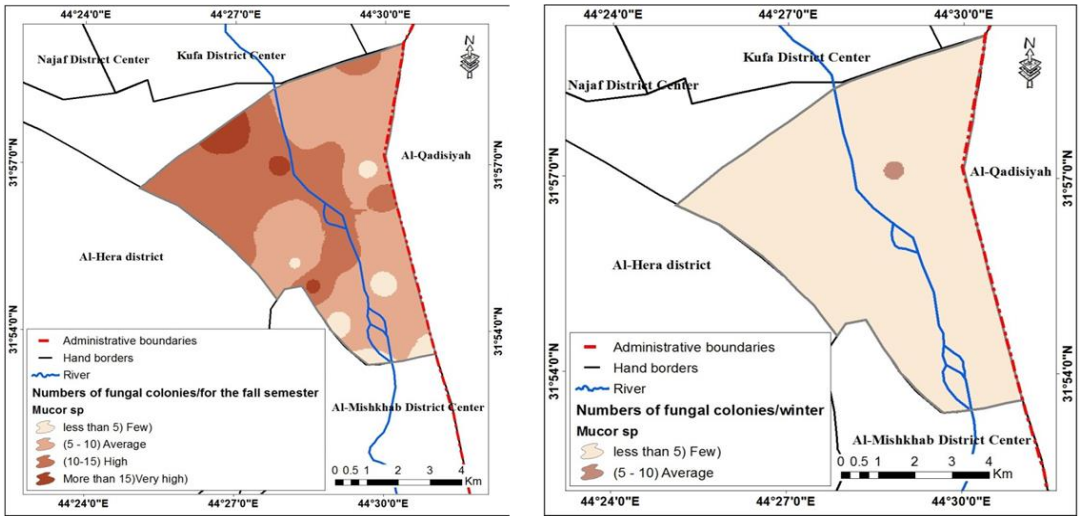
The "Medium" region for this fungus is present in 12 locations (S1, S2, S4, S5, S6, S12, S13, S15, S17, S20, S24, S25), with colony counts ranging from 5 to 9 cells per 1 ml. The spatial distribution covers all parts of the study area. The "High" region is found in 10 sites (S3, S7, S9, S10, S11, S21, S26, S27, S28, S29) with colony counts ranging from 10 to 15 cells per 1 ml. The spatial extension

extends to the northern and western parts of the region. The "Very High" region appears in two locations (S22, S30), with colony counts ranging from 17 to 19 cells per 1 ml. It is mainly situated in the northern part. In contrast, during the winter season, the distribution of this fungus is observed in two regions: "Low" and "Medium." In the "Low" region, it appears in 28 locations (S1, S2, S4, S5, S6, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S31), with colony counts ranging from 0 to 4 cells per 1 ml, totaling 77 colonies. The spatial distribution covers all parts of the study area. This extensive data analysis provides insights into the distribution of Mucor sp in different regions and seasons, offering a detailed understanding of its presence and colony counts in various locations. As for the second region (Medium) of this type of fungus, it appears in 3 sites (S3, S7, S30), with colony counts ranging from 5 to 6 cells per 1 ml. Its spatial distribution is in the central part of the study area. During the spring season, Map 3b show that the distribution of this fungus is categorized into four regions: "Low," "Medium," "High," and "Very High." In the "Low" region, this type of fungus is present in two locations (S14, S24), with colony counts totaling 4 cells per 1 ml from a total of 336 colonies. This season records the highest colony count for Mucor sp, with its spatial distribution being in the central part of the study area. The "Medium" region for this type of fungus is found in 11 locations (S6, S8, S13, S15, S16, S18, S20, S21, S23, S26, S28), with colony counts ranging from 5 to 9 cells per 1 ml. Its spatial distribution extends to the western part, reaching the southern part of the area. The "High" region appears in 14 locations (S2, S4, S5, S10, S11, S12, S17, S19, S22, S25, S27, S29, S30, S31), with colony counts ranging from 10 to 15 cells per 1 ml. Its spatial distribution extends to the northern part, as well as to the eastern and western parts of the region. The "Very High" region is observed in 4 sites (S1, S3, S7, S9), with colony counts ranging from 16 to 21 cells per 1 ml. Its spatial distribution is mainly in the northern part, extending to the central part of the study area. From the provided information, it is evident that this type of fungus does not grow in all studied locations, which is in line with the conditions of suitable temperatures, humidity, and the impact of the region's sewage waste resulting from residential units and restaurants, which directly affects the soil. This fungus can also be transmitted through the use of contaminated surface water for agricultural irrigation, causing plant diseases, especially fruit trees, exposing them to damage. During the summer, despite the high temperatures, this fungus grows due to the increase in agricultural activity, the use of fertilizers in agricultural lands, and their deposition on the soil, creating a suitable environment for its growth. However, in the winter, which records the lowest growth of this fungus, this can be attributed to the decrease in agricultural activity and sewage levels, despite the presence of moisture. Furthermore, industrial activities in these sites, such as workshops for manufacturing doors and windows and car wash stations, do not facilitate the growth of this type of fungus (Maps 4a, b).



a **b**

Map (3) For the Number of Colonies of (Mucor Sp) for A. The Autumn Season, B.The Summer Season.



a b

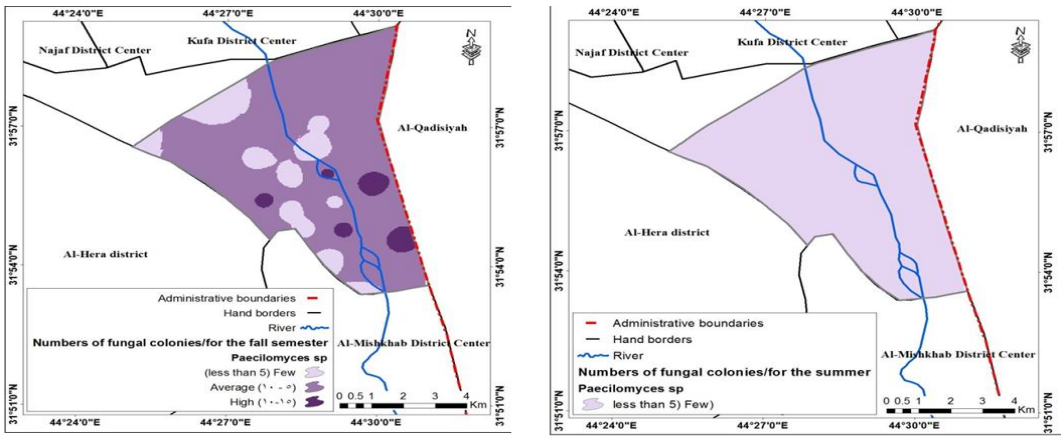
Map (4): For the Number of Colonies of (Mucor Sp) for A. The Spring Season, B. The Winter Season.

Parcilomyces sp Fungus

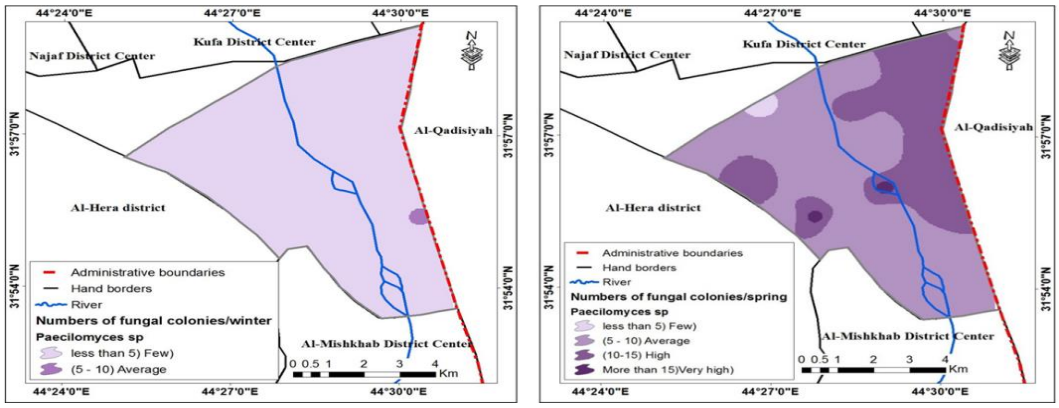
It is a filamentous fungus distributed everywhere, typically found in soil, decomposing plants, threadworms, and the air. This fungus causes numerous diseases in animals, including bronchial and pulmonary inflammation, mild skin inflammation in rats. It also causes human diseases such as corneal inflammation associated with corneal transplantation, sinusitis, pharyngitis after valve replacement, kidney dialysis patients, skin inflammations, lung infections, and fungal blood infections that humans often contract by inhaling air contaminated with this type of fungus. It becomes clear from Maps 5, 6 that there is spatial and temporal variation in soil contamination with Parcilomyces sp. Spatially, it varies from one place to another, and temporally during the seasons. For instance, in the summer season (Map 5), the distribution of this fungus is represented in two regions, "Low" and "Medium." The "Low" region appears in 28 locations (S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, SS14, S16, S17, S18, S19, S21, S22, S23, S24, S25, S27, S28, S29, S30, S31) with colony counts ranging from 0 to 4 cells per 1 ml, out of a total of 63 colonies. This season records the lowest colony count for Parcilomyces sp, and it appears spatially in all parts of the study area.

In the "Medium" region for this fungus (summer season), it appears in 3 sites (S15, S20, S26) with a colony count of 5 cells per 1 ml, extending to the southern part of the region. During the autumn season, as shown in Map 6, the distribution of this fungus is categorized into three regions, "Low," "Medium," and "High." The "Low" region appears in 10 locations (S9, S18, S19, S21, S22, S23, S24, S27, S29, S30) with colony counts ranging from 3 to 4 cells per 1 ml, out of a total of 211 colonies. It appears spatially in scattered parts of the study area, both in the northern and southern parts. In the "Medium" region for this fungus during the autumn season, it appears in 16 locations (S1, S2, S3, S4, S5, S7, S8, S10, S11, S13, S14, S15, S16, S17, S28, S31) with colony counts ranging from 5 to 9 cells per 1 ml, and it appears spatially in all parts of the study area. The "High" region appears in 7 locations (S6, S11, S12, S15, S20, S25,

S26) with colony counts ranging from 10 to 13 cells per 1 ml, and it appears spatially in the southern part of the region. For the winter season, as shown in Map 6, the distribution of this fungus represents two regions, "Low" and "Medium." The "Low" region appears in 25 locations (S3, S4, S5, S6, S9, S10, S11, S12, S14, S16, S17, S18, S19, S20, S21, S22, S23, S24, S26, S27, S28, S29, S30, S31) with colony counts ranging from 0 to 4 cells per 1 ml, out of a total of 75 colonies. It appears spatially in all parts of the study area. The "Medium" region in the winter season appears in 6 sites (S1, S2, S8, S13, S15, S25) with colony counts ranging from 5 to 6 cells per 1 ml, and it appears spatially in the southern part of the region. During the spring season, as shown in Map 6, the distribution of this fungus is categorized into four regions, "Low," "Medium," "High," and "Very High." The "Low" region appears in one site (S30) with a colony count of 4 out of a total of 288 colonies in these sites. This season records the highest colony count for Parcilomyces sp, and it appears spatially in the northern part. The "Medium" region appears in 18 locations (S1, S2, S8, S13, S15, S25) with colony counts ranging between (5-6) cells per 1 ml, and it appears spatially in all parts of the study area. The "High" region is observed in 10 sites (S2, S3, S5, S6, S8, S10, S12, S13, S16, S28) with colony counts ranging from 10 to 15 cells per 1 ml, and it appears spatially in various parts of the region, extending to the northern and eastern parts. The "Very High" region for this fungus appears in two sites (S11, S25) with a colony count of 17 cells per 1 ml, and it appears spatially in the central part of the study area.



Map (5): For the Number of Colonies of (Paecilomyces) for A.The Summer Season, B. The Autumn Season.



Map (6): For the Number of Colonies of (Paecilomyces) for A.The Spring Season, B.The Winter Season.

It becomes clear that this type of fungus does not appear in all the studied locations of the study area, which aligns with the scientific conditions of the region. The highest colony count for this type of fungi in the study area is recorded during the spring and autumn seasons due to the availability of suitable environmental conditions for growth, such as moderate temperatures, appropriate humidity, increased agricultural land area, decomposing plants that create a fertile environment for growth, and the presence of worms in the soil, which are essential for growth. This poses a risk to the residents of the region, especially farmers, as they are exposed to fungal infections when engaging in farming activities or inhaling air contaminated with the fungus. The second rank is given to the summer and winter seasons due to the high temperatures and increased salt concentrations, which inhibit fungal growth and lack of a suitable environment for growth during the winter. Additionally, the decrease in agricultural areas and the reduction of agricultural waste in those areas contribute to this result. From this, it is evident that this type of fungus does not appear in all the studied locations in the study area, which aligns with the scientific reality of the region. It is apparent that the highest recording of colonies of this type of fungi in the study area during the spring and autumn seasons is in the first rank. This is due to the availability of suitable environmental conditions for growth, including moderate temperatures, appropriate relative humidity, an increase in agricultural land area, decomposing plants that provide a fertile environment for growth, and the presence of earthworms in the soil, which are a fundamental factor for growth. This exposes the residents of the area, especially the farmers, to the risk of respiratory and blood infections when engaging in agriculture, inhaling polluted air, or cleaning animals that the microbe can transmit from the soil. However, during the summer and winter seasons, the second rank is observed, with a lower number of colonies of this type of fungus. This is attributed to the high temperatures and increased salt concentrations, which inhibit fungal growth, and the lack of a suitable environment for growth during the winter. Additionally, there is a reduction in agricultural land areas and a decrease in the quantity of agricultural waste during these seasons.

Conclusions

In conclusion, this comprehensive spatial analysis of pathogenic fungi in the Manathira River highlights several key findings. Firstly, the study establishes the presence of spatial and

temporal variations in fungal growth, with different counts observed across various locations and seasons. Urban and agricultural activities significantly influence the proliferation of pathogenic fungi, with higher numbers recorded in areas impacted by these residues. The study also unveils seasonal fluctuations, indicating that fungal counts are highest during the spring and autumn seasons and lowest during the winter and summer. Moreover, the identification of new pathogenic fungi species, such as Mucoracemosus, Fusarium culmorum, and Paecilomyces sp, underscores the need for ongoing research and monitoring in aquatic ecosystems. Ultimately, this research underscores the importance of effective environmental management and pollution control in preserving the health and sustainability of the Manathira River and similar aquatic environments. These findings serve as a valuable resource for decision-makers and environmentalists working towards safeguarding both the environment and public health.

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