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Research article

Study the level of microbial and chemical pollutants in the soil of some densely populated areas of Baghdad

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ABSTRACT

The problem of environmental pollution with heavy metals and pathogenic microorganisms, especially soil contamination, is considered one of the most important public health threats. The current study aims to evaluate the levels of soil contamination in densely populated areas of Baghdad with heavy metals and pathogenic microorganisms and evaluate the incidence of skin infection with different microorganisms in the study areas. Fifty soil samples were collected from different regions of Al-Sadr City and the areas east of the canal. The atomic absorption spectrometer was used to measure the level of heavy metals [Cooper (cu), Zinc (Zn), Lead (Pb), Cadmium (cd), and Mercury (Hg)]. Routine microbiological techniques were used to evaluate the levels of soil contamination with different microorganisms, and the same methods were used to isolate and identify the microorganism causing skin infection in 75 skin swabs collected from outdoor patients of the same study's area. The results of the current study showed that heavy metal levels in the soil samples were below the permissible limits by the United States Environmental Protection Agency (EPA) document. The study also showed that most soil samples were contaminated with microorganisms, particularly normal flora bacteria, at high levels, followed by actinomycetes, whereas contamination with coliform bacteria was very low. The results of microbial examination of the skin showed that the fungal infection was followed by a bacterial infection (Staphylococcal infection), whereas infection with *Escherichia coli* was the lowest. The current study concludes that soil contamination levels in densely populated areas of Baghdad are within acceptable limits. The study also showed that microbial contamination with fecal microorganisms was low.

Keywords: Heavy metals, Microorganism, Pollution, Skin infection.

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1. INTRODUCTION

Soil pollution is one of the most significant environmental problems, with grave implications for public health and the environment at large [1]. The latest study investigated the soil pollution in some samples that were collected from different Iraqi areas. The study highlighted that the study of soil pollution is complex, as it encompasses a range of contaminants, including heavy metals, fertilizers, pesticides, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and pathogenic microorganisms [2,3]. It is also associated with skin infections, as humans are directly in contact with soil, a source of pathogens.

Soil contamination represents an environmental risk with increasingly serious implications in most regions [4]. The rapid and uncontrolled growth generates large amounts of waste and releases toxic and hazardous substances. These chemicals, when ingested or come into contact with humans, animals, and plants, have adverse effects on the environment, threatening the health of humans and animals and the conservation of ecosystems in the short and long term. Different heavy metals exert general effects, but more recently, their primary toxic activities vary across metals. Most frequently, heavy metals reduce and food intake, affect bone

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dimensions, mineralize bone, reduce bone strength, and increase fracture susceptibility (5).

Microbiological contamination of Iraqi urban soils is a significant concern due to the presence of pathogenic bacteria and toxic metals (e.g., lead) originating from landfill sites and industrial pollution. Previous studies in Baghdad have identified bacteria, such as Bacillus, in contaminated soils with high concentrations of total organic carbon (TOC), chemical oxygen demand (COD), total nitrogen (TN), and total phosphorus (TP) [6]. Another study revealed the presence of *Escherichia coli* in groundwater and soil around solid waste disposal sites. This indicated contamination and potential health risks [7]. Heavy metal contamination in urban soils has been found to negatively affect microbial biomass and activity. This shows the complex interactions between soil characteristics and microbial populations [8]. These findings underscore the urgent need for effective measures to mitigate microbiological contamination and heavy-metal pollution in Iraqi urban soils to safeguard public health and the environment.

The present study aims to analyze and estimate heavy metal levels and the prevalence of microbiological contamination in soil samples collected from high-density urban areas in Baghdad and to relate these phenomena with skin infections.

2. MATERIALS and METHODS

2.1. Soil samples

Sterile plastic containers were used to collect soil samples. The sampling sites were selected to represent diverse areas of Al-Sadar city and the eastern regions of Al-Canal (Fig. 1). Fifty soil samples (10-50 gm) were collected from different sites within the study area. The spots were selected at random within the site for sample collection. The samples of soil were collected from the topsoil layer (typically the top 5-15 cm) to capture the most active microbial community and represent the level of chemical contamination of studied areas. The sterilized tool was used to scoop the soil sample into the container. The surface debris and organic matter have to be avoided. Multiple samples were collected across the area of interest and mixed to create a composite sample for a representative analysis. The containers were labeled with unique identifiers, including location, date, depth, and any other relevant information. The samples were Stored in a cool, dark place or refrigerated until processing to maintain microbial viability and to measure heavy metal levels in the investigated areas [9].

2.2. Skin samples

The 75 skin swab samples were collected from patients visiting the hospitals of Al-Sadar city (the must crude population area in Baghdad). The samples were inoculated immediately upon arrival at the hospital laboratories. The patients that samples were collected did not take an antibiotics 72 hours prior he sample collection [10].

2.3. Bacteriological examination

One gram of soil sample was placed in sterile test tubes and 10 ml of sterile normal saline was added. The test tubes were shaken gently. A hundred microliter of suspension was inoculated onto MacConkey agar, Nutrient agar, soil extract agar, and Sabouraud Dextrose Agar (SDA). Biochemical tests, as well as morphological characteristics of colonies, were used to identify the bacterial, yeast, and fungi isolates.

The skin samples were cultured on the nutrient agar, Sabouraud Dextrose Agar (SDA), and Starch Casein Agar (SCA). The phenotypic characteristics of colonies on solid media and the bacterial cells after stained with Gram stain. The biochemical test was used to identify the microorganisms isolated from skin samples [10]. The identified isolates were inoculated onto nutrient agar (37 ^{o}C for 18 h) and stored at 4 ^{o}C for 2 to 4 weeks.

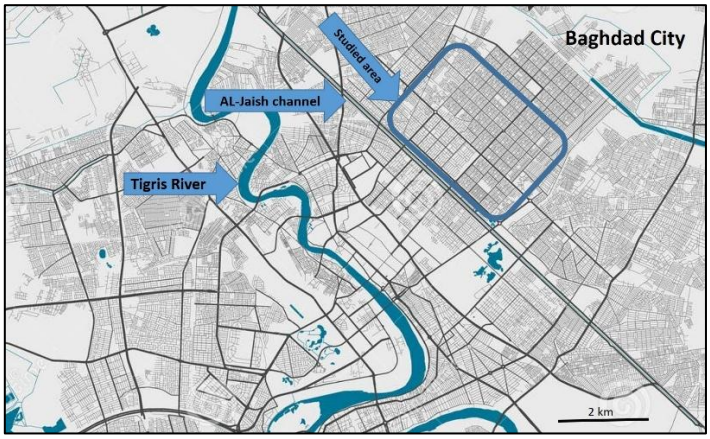

Fig 1. The map of Baghdad shows the study area in Al-Sadar and the eastern regions of Al-Canal.

2.4. Heavy metal evaluation

The standard method of AL-Dulaimi and Younes (2017) was followed to check the heavy metals [copper (Cu), Zinc (Zn), lead (Pb), and cadmium (Cd)] [11]. The atomic absorption spectrometer was used to measure the level of heavy metals [Cooper (cu), Zinc (Zn), Lead (Pb), Cadmium (cd), and Mercury (Hg)]. All heavy metal levels in all soil samples were compared with the maximum permissible limits established by the United States Environmental Protection Agency (EPA) [12].

2.5. Statistical analysis

The mean value has been obtained using all values, and the standard deviation has also been computed. Using Origin 8.0, the differences were examined using Student's t-test. A P value of 0.05 or below was regarded as statistically significant.

3. RESULTS

3.1. Microorganism incidence in soil samples

Fig 2a shows the percentages of microorganisms isolated from soil samples collected in high-density population areas (Al-Sadar city and other eastern Al-canal) in Baghdad. The results showed that most soil samples were contaminated with microorganisms (49 of 50, 98%). Bacteria accounted for the highest percentage of contamination in the soil samples, followed by actinomycetes, whereas fungi accounted for the lowest percentage. The highest percentage of bacterial incidence was observed for bacilli, followed by non-coliform bacilli, whereas the lowest incidence was observed for coliform bacteria (Fig 2b). The present study confirms that most soil samples are contaminated with a bacillus (soil normal flora). In contrast, the current study showed that coliform contamination in the soil is very low, indicating minimal contamination from fecal or wastewater sources.

3.2 Skin pathogenic microorganisms

Fig. 3 shows the numbers and types of microorganisms isolated from skin samples of patients who visited different hospitals in Al-Sader city. The results showed that the highest incidence was with fungi, followed by the number of samples that were infected with staphylococci; the lowest number of infected samples was in the

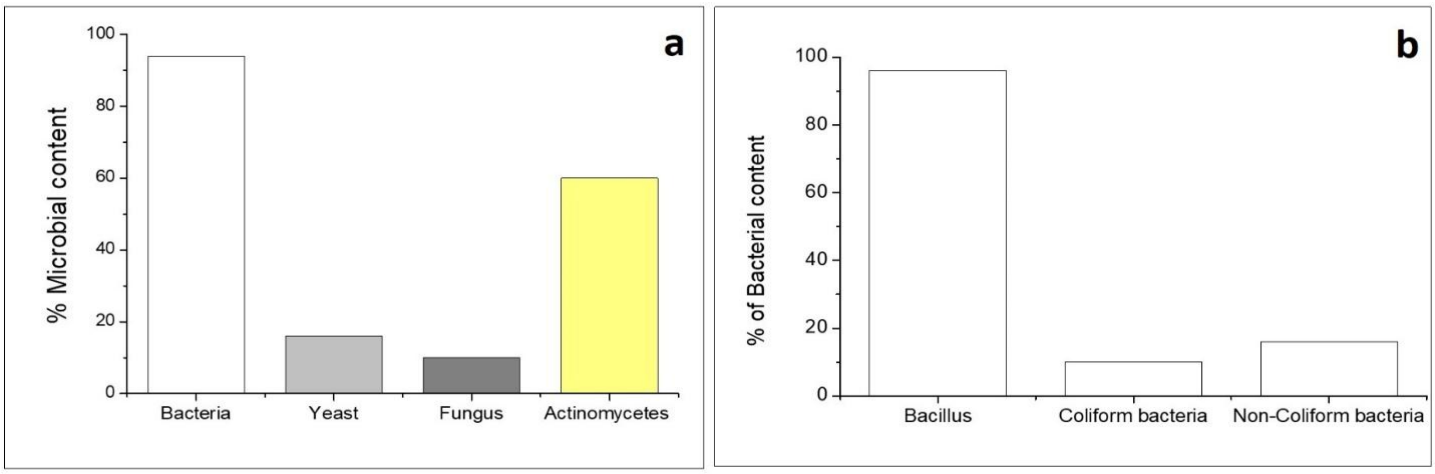

Fig 2. The percentage of the isolation of microorganisms (bacteria, yeasts, fungi, and actinomycetes (a), and the percentage of bacterial species (b) that were isolated from soil samples collected from different areas in Al-Sadar city and the eastern regions of Al-Canal.

case of *E. coli*. The present study did not identify fungal species because deeper microbiological work is needed. The genus of pathogenic bacteria was reported in the current research to provide a general overview of the abundance of pathogenic bacteria. When we sum the number of infected samples, we can see that the number is higher than the total number of collected samples, because of the mix of infection in most cases.

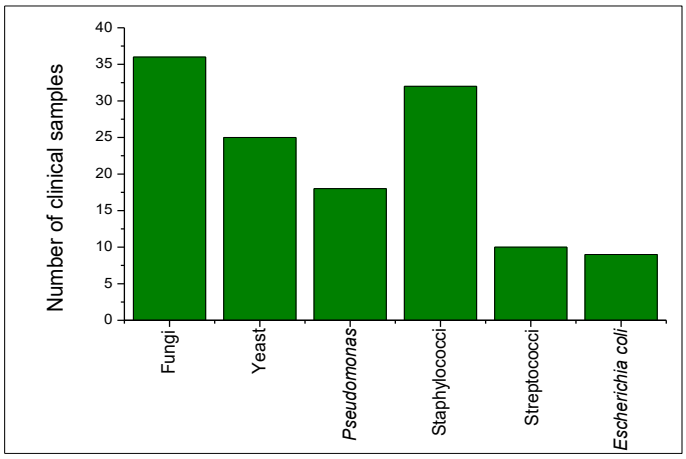

Fig. 3. Number of skin samples that were infected with different microorganisms. Some samples may be contaminated with a mixture of pathogenic microorganisms.

3.3 Levels of heavy metals in soil

Fig 4 shows the concentrations of the main heavy metals [Cooper (cu), Zinc (Zn), Lead (Pb), Cadmium (cd), and Mercury (Hg)] in soil samples collected from different areas (Al-Sadar city and the eastern regions of Al-Canal). The results were compared with the permissible limits for the aforementioned heavy metals reported by the United States Environmental Protection Agency (EPA) (Table 1). The results showed that all levels of the studied heavy metals were below the permitted limits, except for Pb, which was slightly above the EPA-permitted limit.

4. DISCUSSION

The presence of heavy metals affects living organisms and has considerable importance from both health and ecological standpoints. Plants, animals, and human beings are likely to suffer from hepatic, renal, and pulmonary issues due to the ingestion, absorption, or inhalation of heavy metals (13). Several names are applied to microorganisms in or associated with soil and sediment as a group (microbial community, micro flora, soil biota, soil micro biome, and microbial population), and terms such as micro flora, micro biome, and community could refer to the system of interactions between soil and microbes, whilst microorganisms are often characterized as biomass. Soil microorganisms have a fundamental role in soil ecosystem functioning (14).

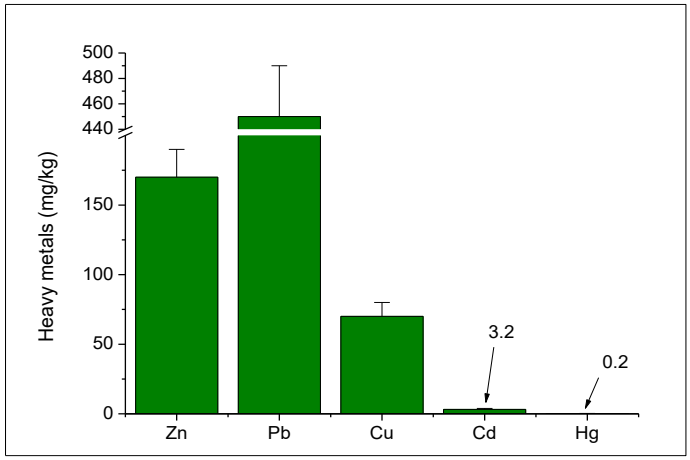

Fig. 4. The levels of heavy metals [Cooper (cu), Zinc (Zn), Lead (Pb), Cadmium (cd), and Mercury (Hg)] in soil samples that were collected from different areas in Al-Sadar city and the eastern regions of Al-Canal.

In the current study, the levels of heavy metals (cu, Zn, Pb, Cd, and Hg) were estimated in soil samples collected from different areas of Al-Sadr City, in addition to the areas east of the canal. It was found that the percentage of heavy metals that were studied fell within the permissible levels according to the published reports of the EPA organization; the levels of lead were slightly higher. The results of the current study showed that most soil samples were contaminated with microorganisms, with bacteria accounting for the highest percentage of contamination, followed by actinomycetes. This is consistent with previous studies conducted in various locations, which have shown soil contamination with a wide spectrum of microorganisms (15). In addition, previous studies showed that the levels of contamination with heavy metals vary from one region to another, and according to the use of the region (16). To link soil contamination to public health, 75 skin samples were collected to examine the microorganisms present.

The results showed the highest infection rates were for fungal infections, followed by staphylococcal infections.

Table 1. The permissible limits for the main heavy metals in soil samples were established by the United States Environmental Protection Agency (EPA).

No	Heavy metals	Permission rang mg/kg
1	Zinc (Zn)	50-200
2	Lead (Pb)	50-400
3	Cooper (Cu)	20-100
4	Cadmium (Cd)	0.5-5
5	Mercury (Hg)	0.1-0.3

Numerous studies showed that industrial sites have more heavy metal pollution than agricultural sites. On the Qinghai–Tibet Plateau and elsewhere in China, heavy metal pollution in industrial zones is notable [17]. The most prevalent and dangerous metals to people and the environment in these areas are Cd, Zn, Cr, Pb, and Cu. Some studies focusing on industrial sites in Shanghai report that, compared to rural sites, industrial zones have a higher pollution of Cd, Hg, and Pb [18]. The industrial zone of concern are the soils and crops as industrialization significantly alters the distribution of heavy metals in soils of the crop soils system, which requires monitoring and controlling of pollution sources to protect the environment and the crops within [19].

In Baghdad, heavy metals and pesticides have been widely reported as contaminants that plague the soil's microbial community. Isolated studies of soil contaminated with pesticides in Baghdad also reported the presence of bacteria, Xanthomonas sp. and Bacillus sp., which are tolerant to chlorpyrifos [20]. Additionally, research has highlighted the presence of heavy metals such as cadmium, nickel, and copper in agricultural soils near the Tigris River, with the use of the Mycorrhizal fungus Glomus mosseae showing promise in removing these contaminants [21]. Furthermore, investigations have detected *E. coli* in groundwater and soil around solid waste disposal sites in Baghdad, indicating contamination that can affect both the environment and public health [22]. These findings underscore the importance of monitoring and remediation efforts to effectively address soil microbial contamination in Baghdad. The recent study in Iraq by Fadhil Alsaffar et al. (2024) found differences in the percentage of microorganism infections compared with the current research; their previous study included parasites and viral infections, whereas the current study included only fungi and bacteria [23]. The present study did not find any relationship between the prevalence of a type of microorganism in the soil and the skin infection of the samples collected from different studied areas, which leads us to the conclusion that the source of skin infection in this area comes from other sources of infection (not soil), such as the work area or contaminated water. The main limitations of the present study are the number of soil and clinical samples, and the fact that the microorganisms isolated should be identified using modern technologies to determine species and subspecies.

5. Conclusion

The present study concluded that all heavy metals were within the normal range, except for lead, which was within a high but narrow range. All samples were contaminated with microorganisms, most of which were members of the normal flora. The fungus was responsible for skin infections in high-density areas of Baghdad, followed by staphylococcal infections. The present study indicates that soil is not the source of skin infection in the study area.

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Conflict of interest

The authors declare that they have no conflict of interest.

Ethical Approval

This study was approved by the scientific and ethical committee of the Ministry of Education, Baghdad, Iraq (No. 7947; October 15, 2023).

CRediT authorship contribution statement

Hameda K. Zgair: Administration, Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Project administration, Resources, Writing – original draft, Writing – review & editing, Supervision.

The author has read and agreed to the published version.

Availability of data and materials

Data will be made available on request

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