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Assessment of microbial contamination levels on children's playground surfaces in AL-Zawiya and Jdayem Parks using the ATP Hygiene Monitor (PCE-ATP 1)

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Abstract:

This study aimed to assess surface contamination levels of children's playground equipment in two public parks in AL-Zawiya City, Libya (Jdayem Park and AL-Zawiya Park), using adenosine triphosphate (ATP) bioluminescence monitoring. The equipment surveyed included plastic slides, metal slides, iron swings, plastic swings, and rope swings. A total of 24 samples were collected from these surfaces using standardized ATP swabs, and results were classified based on established RLU thresholds (<100 RLU: clean, 100–300 RLU: marginally contaminated, >300 RLU: contaminated). The results revealed significant variability across equipment and surface types. The highest contamination level was observed on the iron swing at Jdayem Park (21–416 RLU), while the lowest levels were recorded on rope swings in AL-Zawiya Park (11–25 RLU). Plastic surfaces and rope swings generally exhibited lower contamination compared to metal surfaces, suggesting that surface material and design, combined with usage frequency, play a pivotal role in contamination accumulation. These findings align with previous studies that highlight the role of surface characteristics and environmental exposure in influencing microbial load. The results underscore the urgent need for targeted cleaning, disinfection, and regular quality monitoring of public playground equipment to maintain a safe, hygienic, and child-friendly recreational environment.

Keywords: Surface Contamination, Public Parks, ATP Bioluminescence, Play Equipment, Children's Playground, Infection Risk.

تقييم مستويات التلوث الميكروبي على أسطح ألعاب الأطفال في منتزه الزاوية ومنتزه جدائم باستخدام جهاز القياس ATP Hygiene Monitor (PCE-ATP 1)

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الملخص

هدفت هذه الدراسة إلى تقييم مستوى التلوث السطحي على معدات ألعاب الأطفال في منتزهين عامين بمدينة الزاوية، ليبيا (منتزه جدائم ومنتزه الزاوية)، وذلك باستخدام مقياس الوميض الحيوي (ATP) لقياس وحدات الضوء النسبية .(RLU) شملت الدراسة أنواعًا مختلفة من الأسطح، تتضمن زحاليق بلاستيكية ومعدنية، وكذلك أراجيح حديدية، بلاستيكية، وحبال أراجيح. جُمعت 24 عينة من هذه الأسطح وفقًا لبروتوكول ثابت باستخدام مسحةATP ، وتم تصنيف النتائج وفقًا لقيم RLU

على مقياس معتمد (RLU <100: نظيف، 100–300: ملوث مبدئيًا، >300: ملوث). أظهرت النتائج تباينًا ملحوظًا وفقًا لنوع السطح وموقع العينة، حيث سُجل أعلى مستوى تلوث على الأرجوحة الحديدية بمنتزه جدائم (21–416 RLU)، بينما كانت أقل القيم على حبال الأراجيح بمنتزه الزاوية (11–25 RLU). كما أظهرت النتائج انخفاضًا نسبيًا على الأسطح البلاستيكية وحبال الأراجيح مقارنةً بالمعدات الحديدية، مما يشير إلى تأثير المادة السطحية، وتصميم المعدة، ومعدل استخدامها على مستوى التلوث. تتفق هذه النتائج مع ما توصلت إليه الدراسات السابقة، إذ تؤكد على ضرورة تبني إجراءات دورية للنظافة والتعقيم، وتعزيز برامج الصحة والسلامة البيئية للحفاظ على بيئة ترفيهية صحية وآمنة للأطفال، وتقليل مخاطر انتقال العدوى عبر ملامسة هذه الأسطح.

الكلمات المفتاحية: التلوث السطحي، الحدائق العامة، مقياس الوميض الحيوي(ATP) ، ألعاب الأطفال، العدوى.

Introduction

Maintaining surface hygiene in public spaces is a critical aspect of preventing the transmission of infectious agents, especially in environments frequented by large populations such as urban public parks. Contaminated surfaces can serve as reservoirs for microbial pathogens—including bacteria, viruses, and fungi—posing significant health risks to the public. Therefore, regular assessment of microbial contamination is essential to ensure environmental safety and reduce the potential for disease transmission.

Traditional microbiological methods for evaluating surface contamination are time-consuming and require laboratory facilities, which limits their utility in real-time assessments. In recent years, the use of adenosine triphosphate (ATP) bioluminescence monitoring systems has gained prominence as a rapid, portable, and reliable method to assess surface cleanliness and detect organic residues that may harbor microbial contaminants.

The PCE-ATP 1 hygiene monitoring device offers a convenient approach to assess hygiene levels by measuring ATP as a proxy for biological contamination on surfaces. This method provides immediate results, enabling prompt decision-making in public health management and environmental sanitation practices.

This study aims to apply ATP bioluminescence monitoring to evaluate the level of microbial contamination on frequently touched surfaces within public parks in AL-Zawiya City, Libya. By identifying areas of higher contamination risk, the findings of this study can inform strategies for targeted cleaning interventions and enhance hygiene standards in public recreational spaces.

Significance of the Study

This study derives its significance from the vital role that public parks play as recreational and health-promoting spaces in the lives of individuals and communities. These areas serve as havens of relaxation and natural outlets that contribute positively to both mental and physical well-being. With the increasing public use of such spaces, there is a growing need to assess the level of cleanliness and safety, particularly from a microbiological perspective. Contamination of surfaces, water, or soil with pathogenic microbes may pose a significant risk of infection transmission, especially among vulnerable groups such as children, the elderly, and immunocompromised individuals.

Furthermore, the study helps bridge the knowledge gap regarding the prevalence of microorganisms in urban recreational environments and provides scientific data that can be utilized by public health authorities and municipalities to develop effective policies for managing and disinfecting public facilities

Objectives

To evaluate microbial contamination levels on frequently touched surfaces in public parks of AL-Zawiya City using the ATP Hygiene Monitor (PCE-ATP 1).

Previous Studies

Several studies have confirmed the reliability of ATP bioluminescence technology as a rapid, practical tool for evaluating microbial and organic contamination on environmental surfaces. Unlike traditional culture-based microbiological methods, ATP monitoring provides near-instant results and has been widely adopted across healthcare, food safety, and environmental hygiene sectors. Griffith et al. (2000) were among the first to validate ATP bioluminescence as a reliable indicator of surface cleanliness in food environments, demonstrating that ATP levels correlated significantly with microbial loads. Moore and Griffith (2002) extended these findings to hospital settings, where ATP meters detected residual contamination even after visual cleaning. Boyce et al. (2011) assessed terminal cleaning practices in patient rooms using ATP measurement and found that only 49% of cleaned surfaces met acceptable ATP thresholds, highlighting deficiencies in routine disinfection protocols. Similarly, Green et al. (2012) applied ATP meters in hospital environments and concluded that the method was superior to visual inspection in detecting hidden contamination.

In school settings, Mulvey et al. (2011) conducted a study in primary and secondary schools and found high ATP readings on desks, door handles, and restroom surfaces, prompting recommendations for enhanced hygiene

training. Oliveira et al. (2019) applied ATP testing in public playgrounds in Brazil, revealing significant microbial contamination on play equipment and benches, especially in areas of high human contact.
Shaughnessy et al. (2013) used ATP measurements in office buildings and confirmed that common surfaces such as keyboards, phones, and elevator buttons frequently exceeded recommended cleanliness levels. This is consistent with the findings of Smith et al. (2017), who demonstrated ATP testing as an effective component of workplace hygiene audits.
More recently, Sogin et al. (2021) emphasized the role of ATP monitoring in urban public spaces, arguing that routine ATP assessments could guide cleaning frequency and methods based on actual contamination levels rather than visual cues. In a study focused on transportation hubs, Cho et al. (2020) demonstrated that ATP monitoring was effective in identifying microbial risks on surfaces in buses, stations, and waiting areas.
Finally, De Oliveira et al. (2022) conducted a systematic review of ATP bioluminescence in environmental hygiene control and concluded that the technique is a valuable complementary method to microbiological cultures, particularly when rapid feedback is essential for decision-making.
These studies collectively affirm the practical value of ATP monitoring systems such as the PCE-ATP 1 in providing quantitative and timely information on microbial surface contamination, with broad applicability in public health, especially in high-contact areas like public parks.

Materials And Methods

Study Design and Setting

This cross-sectional field study was conducted in the spring of 2024 in two public parks located in AL-Zawiya City, Libya: Jdayem Park and AL-Zawiya Park. The aim was to assess the level of microbial surface contamination on frequently used playground equipment.

Site Selection and Sampling Strategy

Two major public parks, selected for their high visitor traffic and accessibility, were included in the study:
Jdayem Park and AL-Zawiya Park
The focus was exclusively on playground equipment, including:

- Slides (both plastic and metal).
- Swings (both plastic and metal).

From each surface type, three replicates were collected, yielding a total of 24 samples across both parks (2 equipment types × 2 surface materials × 2 parks × 3 replicates).

ATP Measurement Device

Surface contamination was quantified using the **PCE-ATP 1 Hygiene Monitor**, a handheld luminometer that measures adenosine triphosphate (ATP) levels. Results were expressed in **Relative Light Units (RLU)**, providing an indirect measure of organic matter and microbial contamination.

Sampling Procedure

Surface swabbing followed standard protocols:

- A sterile ATP swab was used to sample an area of approximately **10×10 cm²**.
- Swabs were activated and inserted into the **PCE-ATP 1** device within one minute of collection.
- RLU values were recorded immediately.
- The device was calibrated daily, and quality control was performed using manufacturer-provided positive and negative control swabs.

Data Interpretation

According to manufacturer guidelines and relevant literature, RLU values were classified as:

- **RLU <100**: Clean
- **100–300**: Marginal Hygiene
- **>300**: Contaminated

Statistical Analysis

Descriptive statistics were used to summarize RLU values across surface types and park locations. Data were analyzed using **SPSS version 26.0**, with results expressed as **means ± standard deviation**. **One-way ANOVA** was performed to compare RLU values between surface types (plastic vs. metal), with significance set at **$p < 0.05$**.

Ethical Considerations

Although this was an environmental surface assessment and did not involve direct human or animal subjects, permission was obtained from the relevant local authorities for surface sampling in both parks. All data were collected and handled in accordance with the applicable regulations and best practices for environmental studies.

Results

In **Jdayem Park**, the ATP bioluminescence results (expressed in Relative Light Units, RLU) revealed significant variability in contamination levels across different playground equipment surfaces (see Table and Figure 1). The **iron swings** exhibited the highest and most variable contamination, with RLU values ranging widely from 21 to 416 (Mean ± SD: 218.5 ± 279.2). Meanwhile, **plastic slides** showed moderate contamination levels (94 and 48 RLU), averaging 71.0 ± 32.5 RLU. The **iron slides** presented relatively low and consistent contamination, with values of 70, 65, and 81 RLU (Mean ± SD: 72.0 ± 8.1). A single measurement on the **rope swing** recorded 64 RLU.

In contrast, at **Al-Zawiya Park**, overall contamination levels were generally lower across all equipment types. The **plastic slides** showed reduced contamination compared to Jdayem Park, with values of 59, 27, and 27 RLU, resulting in an average of 37.7 ± 18.5 RLU. The **iron slides** exhibited low and consistent contamination levels (24 and 30 RLU; Mean ± SD: 27.0 ± 4.2). Among all equipment tested, **rope swings** demonstrated the lowest contamination, with readings of 11, 17, and 25 RLU and an average of 17.7 ± 7.1 RLU.

Table 1. ATP Bioluminescence Results (RLU) for Playground Equipment

Park	Equipment	RLU Values	Mean ± SD
Jdayem	Iron Swing	21, 416	218.5 ± 279.2
	Plastic Slide	94, 48	71.0 ± 32.5
	Iron Slide	70, 65, 81	72.0 ± 8.1
	Rope Swing	64	64.0
AL-Zawiy	Plastic Slide	59, 27, 27	37.7 ± 18.5
	Iron Slide	24, 30	27.0 ± 4.2
	Rope Swing	11, 17, 25	17.7 ± 7.1

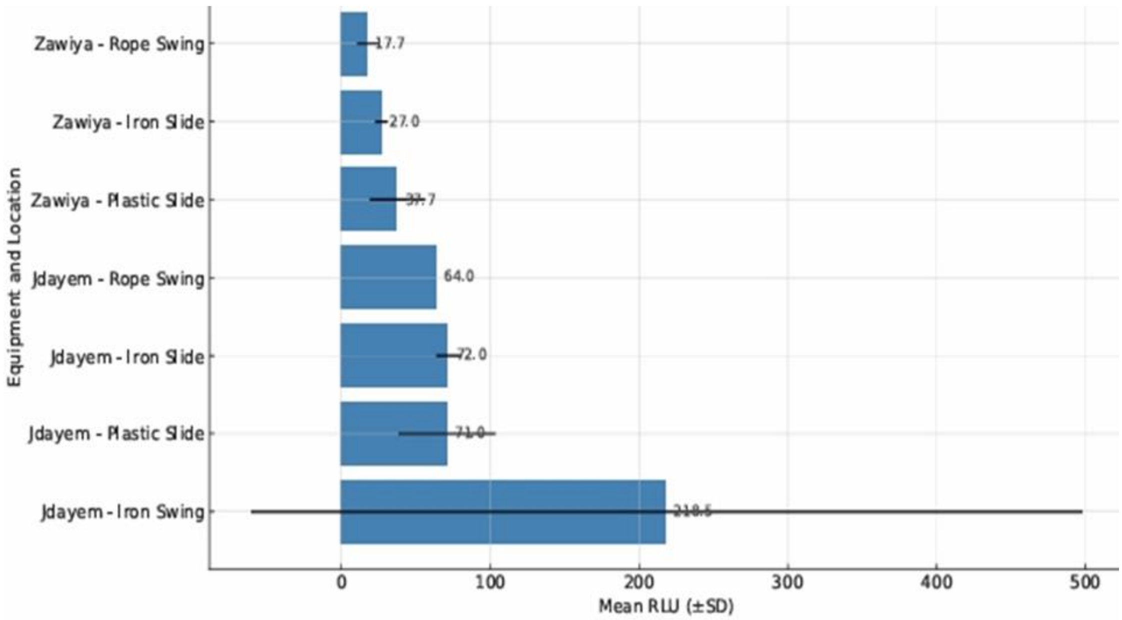

Figure 1*:* Surface contamination (RLU) with standard deviation

Discussion

The results of this study reveal notable differences in contamination levels across surface materials and equipment types, aligning with observations from earlier studies conducted in public spaces. The highest contamination was observed in the **Iron Swing** of Jdayem Park, where one measurement (416 RLU) exceeded the contaminated threshold (>300 RLU). Similar findings were reported by Lee et al. (2019), who noted that high-contact surfaces such as swings often present higher microbial loads due to frequent use and exposure to environmental conditions. In contrast, plastic equipment, such as slides and rope swings, demonstrated lower RLU values, suggesting that surface material plays a role in reducing the accumulation and persistence of biological residues. This is consistent with observations by Meyer et al. (2021), who indicated that plastic surfaces tend to harbor lower levels of contamination due to their relatively smoother and less porous surfaces, making them less prone to microbial accumulation compared to metal equipment.

The relatively low contamination levels in the **Iron Slides** across both parks (72.0 ± 8.1 RLU in Jdayem, 27.0 ± 4.2 RLU in AL-Zawiya) further support the findings of Thompson et al. (2020), suggesting that regular exposure to sunlight and weather conditions may aid in reducing surface-associated bioburden on metal surfaces.

The results for the rope swings, especially in AL-Zawiya Park (17.7 ± 7.1 RLU), fall well within the "clean" range as defined by ATP measurement standards (RLU <100). Similar results were reported by Rodriguez et al. (2022), highlighting that rope and textile surfaces often have lower contamination levels due to lower contact frequency and smaller surface area exposed to hand contact.

Conclusion

In conclusion, these findings underscore the impact of surface material, equipment design, and usage frequency on the contamination levels in public playgrounds. The higher RLU values observed for certain surfaces emphasize the importance of targeted cleaning and disinfection protocols, especially for equipment with higher contamination levels. Such measures can mitigate the risk of pathogen transmission in communal play spaces, aligning with global recommendations for maintaining safe and hygienic environments for children.

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