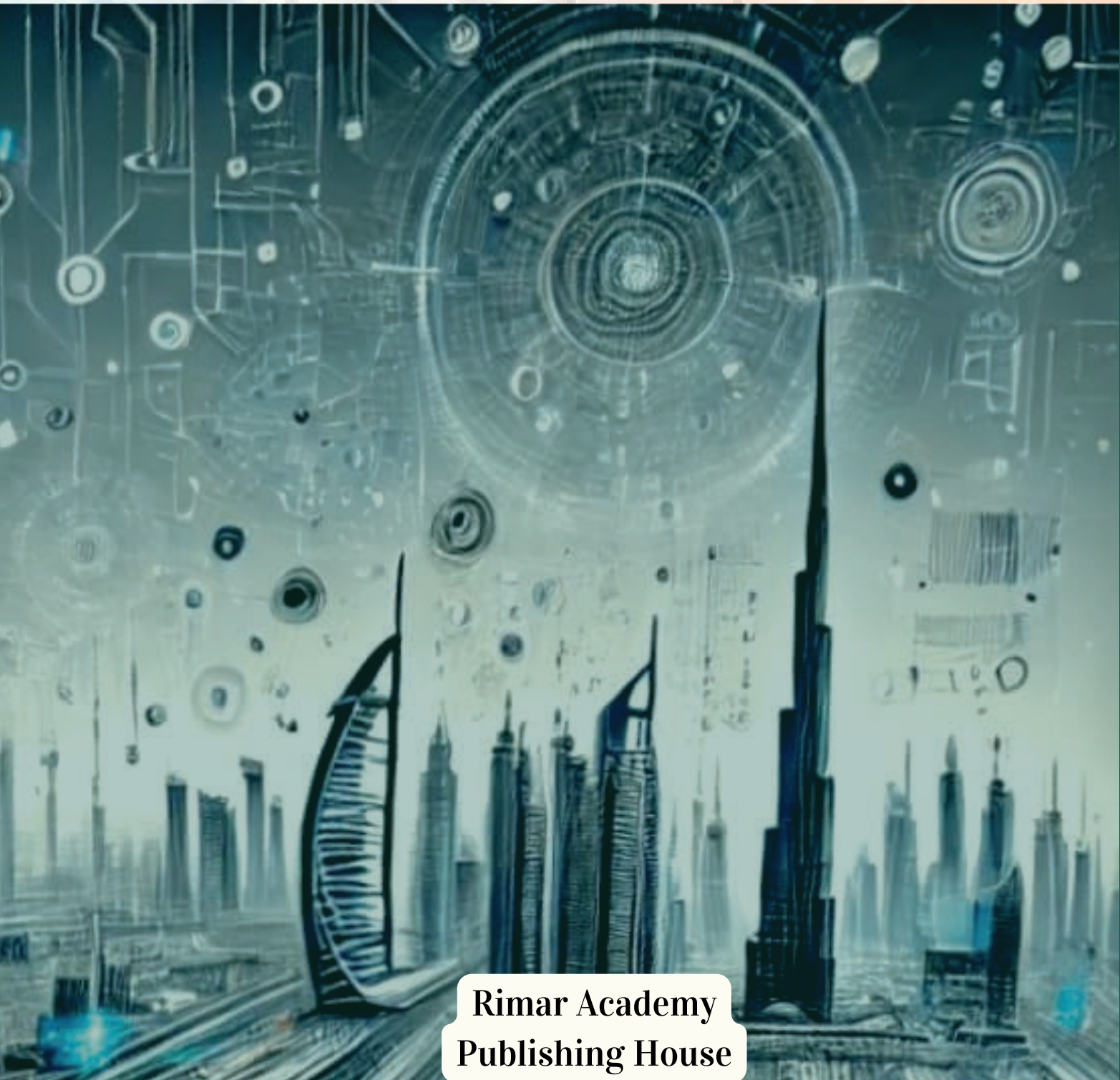


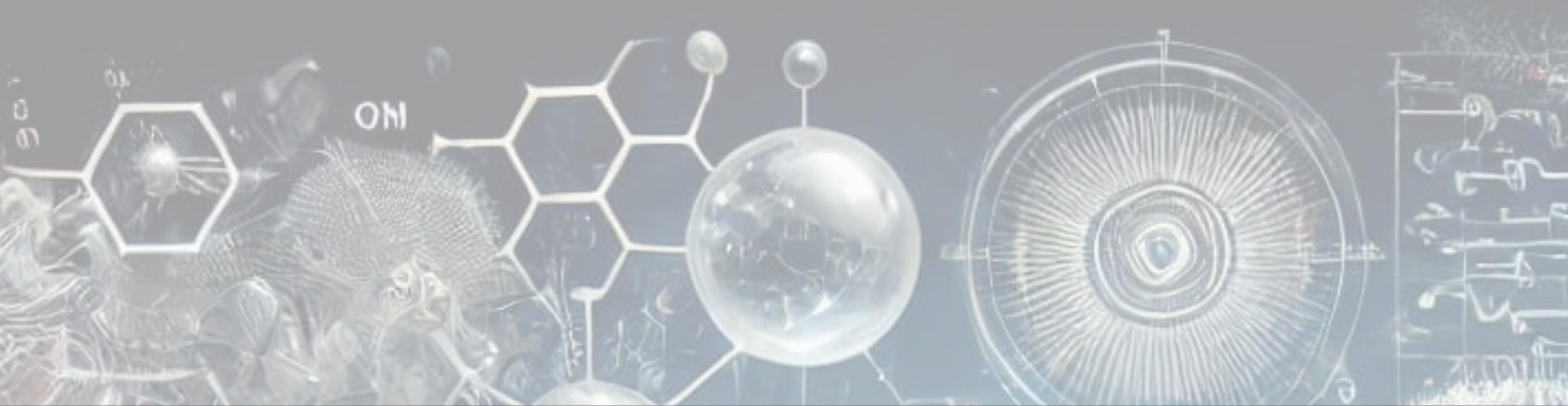
# مؤتمر دبي الدولي الثاني للعلوم التطبيقية والصرفة والتكنولوجية

## II. Dubai International Conference of Pure, Applied and Technological Sciences

## II. Dubai Uluslararası Fen, Uygulamalı ve Teknolojik Araştırmalar Kongresi







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# PREFACE

II. Dubai International Conference of Pure, Applied and Technological Sciences was organized by Igdır University in collaboration with Rimar Academy. The primary objective of this event was to compile and disseminate valuable scientific knowledge and make a meaningful contribution to the future.

A substantial number of researchers from both local and international backgrounds demonstrated their interest in this conference. The scientific committee meticulously reviewed the submissions and ultimately accepted a select group of applicants—**37** in total—of whom **30** were approved by the scientific committee.

The core of this conference was the presentation of **17** full research papers, while the remaining articles and research findings are set to be featured in forthcoming issues of the MINAR Journal.

I would like to extend my sincere appreciation to all the contributors and scholars who played an essential role in making this conference a resounding success. Your dedication and valuable contributions are deeply respected and acknowledged.

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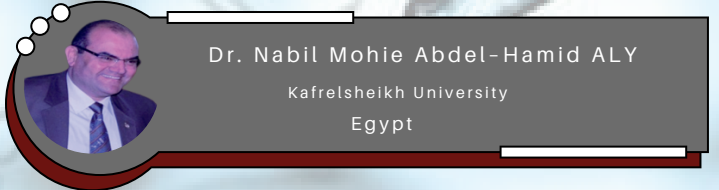
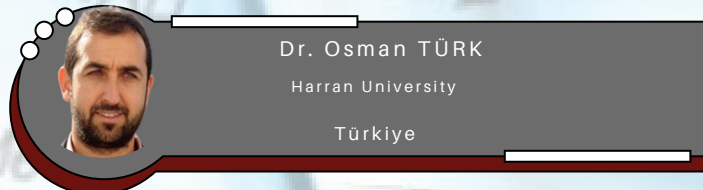
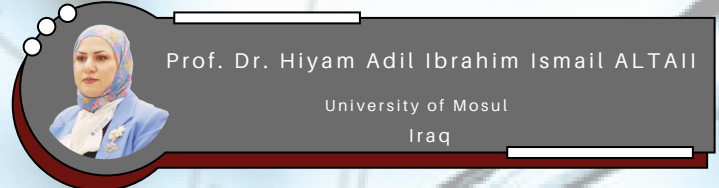
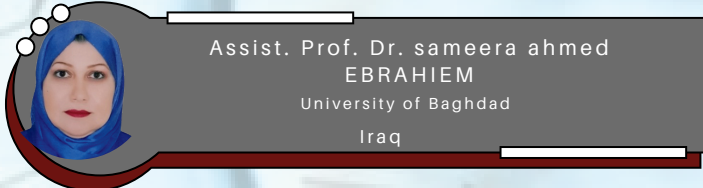
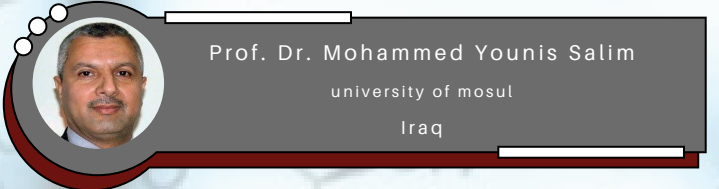
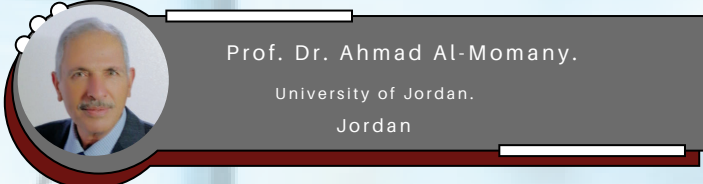
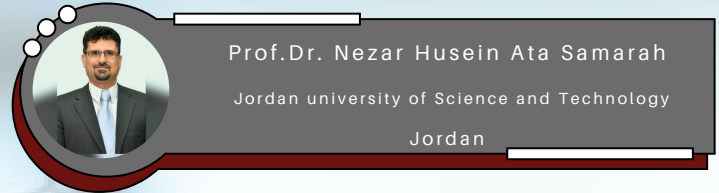
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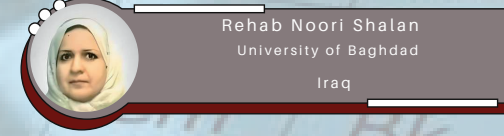
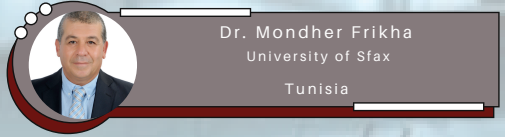
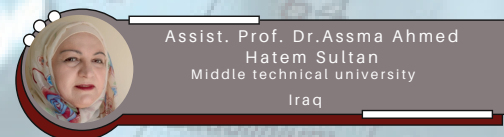
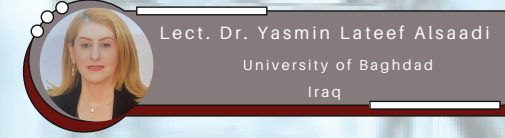
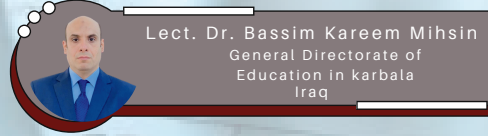
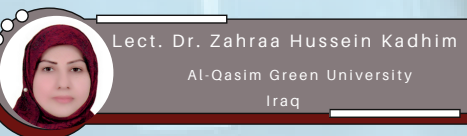
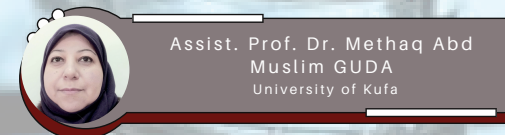
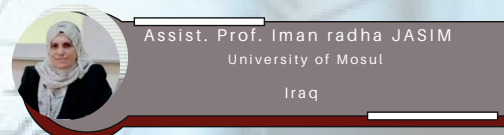
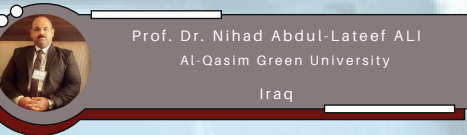
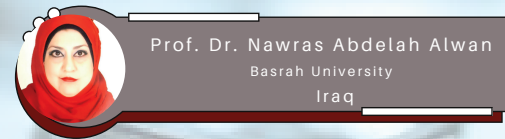
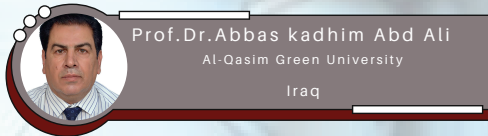
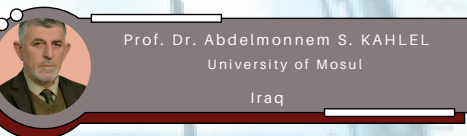
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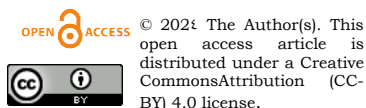




## Molecular Epidemiology and Risk Factors for Carbapenem-Resistant *Acinetobacter baumannii* Infections in an Intensive Care Unit

Bashaer Saad Jabbar <sup>1</sup>

Ibtihal Riyad <sup>2</sup>




### Abstract

Carbapenem-resistant *Acinetobacter baumannii* (CRAB) poses a significant threat to global health, particularly in intensive care units (ICUs). This study investigated the molecular epidemiology and risk factors associated with CRAB infections in four Iraqi ICUs. A total of 164 patients with invasive MDR *A. baumannii* infections were included. Demographic and clinical data were collected prospectively, and antimicrobial susceptibility testing was performed on 172 isolates (164 clinical and 8 environmental). Multiplex PCR was used to identify four key carbapenem resistance genes. The study revealed a high mortality rate (56.4%) among infected patients. The majority were male (51.6%), admitted to surgical ICUs (44.2%), and had undergone invasive procedures, including urinary catheterization (97.4%) and mechanical ventilation (67.3%). Univariate analysis identified older age (>65 years), diabetes mellitus, chronic liver failure, and prior chemotherapy treatment as independent risk factors for mortality. Antimicrobial susceptibility testing revealed alarmingly high resistance rates (>90%) to most tested antibiotics, including amikacin, ampicillin-sulbactam, ceftazidime, ciprofloxacin, and imipenem. Colistin exhibited the lowest resistance (2.2%). *blaOXA-23* was the most prevalent resistance gene detected across all centers, with significantly higher frequencies in two centers. These findings emphasize the critical need for effective infection control measures, judicious antibiotic stewardship, and continuous surveillance of resistance patterns to combat the spread of MDR *A. baumannii* in healthcare settings. Furthermore, the development of novel therapeutic strategies is crucial to address the limited treatment options for this increasingly resistant pathogen.

**Keywords:** *Epidemiology, Acinetobacter Baumannii, Care Unit, Patients.*

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## 1.Introduction

Resistance to the carbapenem strain of *Acinetobacter baumannii* has been a major cause for health concern around the world for the past few years (Jiang et al., 2022). This is especially significant in the intensive care unit because this is the population that is most exposed to nosocomial infection (Pompilio et al., 2021). *A. baumannii* is a Gram-negative bacterium known to cause severe infections such as ventilator-associated pneumonia, bloodstream infections, and urinary tract infections (Jiang et al., 2022; Pompilio et al., 2021). The development of carbapenem resistance in *A. baumannii* is a "critical" pathogen of the World Health Organization priority list of organisms in terms of research and development of new antibiotic options, where treatment options for *baumannii* infection are severely limited.

The epidemiology of CRAB focuses on the molecular characteristics of the pathogens, its genetic relatedness, and clonal clusters that is important in following the spread of the resistant strains as well as in formulating the strategies for control of the infections (Eddy et al., 2007). Research has revealed that there are several strains of *A. baumannii* and that some of these are clones including the second clone that is known to be prevalent and is known to be linked with multi-drug resistance genes (Palmieri et al., 2020). For example, the investigations of Sudanese Khartoum isolates at the molecular level showed that 70% belong to group 2 and were found to contain both chromosomal and acquired carbapenemases including OXA 66 and OXA 23 (Palmieri et al., 2020). Such effects have been also documented in other parts of the world showing the international nature of this issue (Jones et al., 2008).

This has provided the basis to understand the risk factors for CRAB infections in ICUs which also include the patient characteristics as well as the environment factors (Abubakar et al., 2022). Others are patient-related factors that include long hospital stay, use of invasive medical devices like the ventilator or the central line, and previous contact with antibiotics (Meschiari et al., 2021). This is compounded by poor infection control practices, sterilization and disinfection procedures as well as emergence of CRAB on hospital surfaces are today's key environmental variables that significantly contribute in the spread these infections (Seok et al., 2021). That is why the identification of these risk factors is crucial for future successful programs of prevention aimed to minimize the rates of CRAB infections (Farag et al., 2023).

Mechanisms through which carbapenem resistance occurs in *A. baumannii* are therefore multiple and at the molecular level (Khurshid et al., 2019). These are carbapenemases; OXA-23, OXA-24/40, and NDM-1 and other mechanism are reduced permeability arises from alteration in porin-like protein and enhanced efflux pumps activity (Müller, 2018). These

resistance mechanisms may work individually or in concert in clinical isolates adding to the development of appropriate treatment strategies for the infections; the necessity for broad molecular tracking to note the appearance and distribution of resistant strains is therefore highly underlined (Islam et al., 2024).

The management of CRAB infection within the ICU must have improved infection control, better molecular surveillance and evaluation for newer therapeutic interventions (Jiang et al., 2022). Molecular epidemiological research plays the central role in this regard since it offers clues as to the clonal relatedness and population genetic characteristics of the CRAB isolates (Dahdouh, 2017). Appreciation of the local and global epidemiology will enhance the management and infection control practices regarding the spread of these resistant bacteria hence reducing the morbidity and mortality of patients who develop CRAB infections in intensive care units.

## **2. Materials and Methods**

### **2.1 Designing the study:**

The study was undertaken at four distinct medical centers in fregions (Iraq) 2024. The study included all patients hospitalized to medical facilities' intensive care units with invasive *A. baumannii* infections. The non-interventional clinical research ethics committee of Iraq examined and approved the study.

### **2.2 Patient traits and risk factors:**

164 people with *A. baumannii* diagnoses, both clinically and microbiologically, had their characteristics and risk factors examined. Data were taken from a standardized case report form in the future. Age, sex, employment, immunosuppression, underlying condition, past hospitalization, number of days spent in the unit, invasive procedures or surgery performed within 30 days after diagnosis, previous antibiotic therapy, and treatment success were all reported by all facilities. Central and urinary catheterization, artificial breathing, nasogastric tube implantation, and orotracheal intubation were among the invasive operations performed.

### **2.3 Sample collection and isolation identification:**

Twelve environmental and 164 clinical *A. baumannii* isolates were included in the study. in four separate locations all over Iraq. Every patient suffered from a monomicrobial MDR *A. baumannii* infection. Samples from blood (89%) and a variety of sterile body sites (pleural fluid, tissue, bronchoalveolar lavage fluid (BAL), cerebrospinal fluid (CSF), and catheter) were used



to obtain clinical isolates from patients admitted to intensive care units for medicine and surgery. In every ICU, the surfaces of tables, sinks, faucets, and pumps were sampled for the environment.

#### **2.4 Antimicrobial susceptibility tests:**

Following the criteria of the Clinical Laboratory Standards Institute (CLSI), antimicrobial susceptibility tests were conducted for six antimicrobials: ampicillin-sulbactam (SAM), amikacin (AN), ceftazidime (CAZ), ciprofloxacin (CIP), imipenem (IMP), and colistin (COL). The broth microdilution technique was utilized for these tests. With the exception of the sulbactam-ampicillin test, all antibiotic susceptibility tests were conducted using the reference control strain of *Pseudomonas aeruginosa* ATCC 27853. The reference control for this antibiotic was *Escherichia coli* ATCC 35218. Furthermore, Etest (bioMérieux, France) antibiotic gradient strips were utilized to determine the tigecycline (TIG) minimum inhibitory concentration (MIC) value.  $> 4$  mg/L was considered resistant, and TIG break thresholds of less than 1 mg/L were considered susceptible. FDA-approved breakpoints listed in the package insert were used to assess MIC values against tigecycline (Boral et al., 2019).

#### **2.5. Detecting antibiotic resistance genes**

Resistance genes were found using two different multiplex PCR techniques: one for blaIMP, blaNDM, blaKPC, and blaOXA-48 in all 172 isolates, and another for blaOXA-23, blaOXA-24, blaOXA-51, and blaOXA-58. Utilizing a method, the blaPER-1 gene's existence was also verified. 12.5  $\mu$ L of Taq PCR master mix (New England Biolabs, Beverly, MA) was added to each PCR reaction (25  $\mu$ L). For each primer (0.5  $\mu$ L, final concentration 2  $\mu$ M), use 5.5  $\mu$ L of sterile, RNase-free water, and 2  $\mu$ L of the DNA template. 2% agarose gel was used to observe the amplified products (Boral et al., 2019).

#### **2.6 Statistical analysis:**

In the research group, we employed univariate conditional logistic regressions. Odds ratios were calculated by exponentiating regression coefficients and reporting their 95% confidence intervals. To account for confounding effects, variables having a p-value less than 10% significance in univariate analysis were included in multiple conditional logistic regression models.

### 3. Results

#### 3.1 features of the patients and risk factors:

The study observed a high mortality rate (56.4%) among patients with invasive MDR *A. baumannii* infections. The majority of patients were male (51.6%) and admitted to surgical ICUs (44.2%). Nearly all patients (97.4%) had urinary catheters, while a significant proportion also had central catheters (73.4%) and mechanical ventilation (67.3%). This information provides a valuable overview of the patient population included in the study and highlights the prevalence of certain risk factors, such as invasive procedures, which may contribute to the development and severity of MDR *A. baumannii* infections in ICU settings as show in table 1.

**Table 1. The patients' demographic characteristics and risk factors (n = 164)**

	<b>NO.</b>	<b>How often (%)</b>
<b>Gender</b>		
<b>Male</b>	87	51.5
<b>Female</b>	77	45.2
<b>Provision of services</b>		
<b>Intensive Care Units</b>	60	29.5
<b>Surgical ICUs</b>	77	44.2
<b>Burn ICUs</b>	18	9.2
<b>Emergency assistance</b>	9	17.1
<b>suppression of the immune system</b>		
<b>Corticosteroid usage</b>	19	10
<b>Transplantation</b>	—	—
<b>Chemotherapy</b>	18	8.1
<b>invasive techniques</b>		
<b>Central catheterisation</b>	123	73.4
<b>catheterization of the urinary system</b>	163	97.4
<b>Mechanical ventilation</b>	122	67.3
<b>Nasogastric tube</b>	83	55.2



<b>Intubation of the orotrachea</b>	72	43.1
<b>Other</b>	31	14.4
<b>Mortality</b>	94	56.4

**ICU intensive care unit**

### 3.2 The risk factors of mortality:

Table 2 presents the risk factors for mortality among the 164 patients with invasive MDR *Acinetobacter baumannii* infections. Univariate analysis revealed a statistically significant association between mortality and age over 65 (Risk Ratio 1.243,  $p = 0.082$ ), diabetes mellitus (Risk Ratio 2.556,  $p = 0.016$ ), chronic liver failure (Risk Ratio 4.921,  $p = 0.027$ ) and prior chemotherapy treatment (Risk Ratio 3.145,  $p = 0.035$ ). No significant association was found between mortality and gender, other comorbidities, or invasive procedures. These results suggest that older age, diabetes mellitus, chronic liver failure, and prior exposure to chemotherapy may be independent risk factors for mortality in patients with invasive MDR *A. baumannii* infections.

**Table 2. The mortality risk variables for patients (n = 164)**

	<b>Mortality (n = 96)</b>	<b>Survival (n = 68)</b>	<b>Analysis of univariate data Risk ratio (%95 CI)</b>	<b>p value</b>
<b>Characteristics of the population</b>				
<b>Age</b>			2.357	0.011
<b>&lt; 64</b>	37	55		
<b>&gt; 65</b>	56	22		
<b>Gender</b>			1.243	0.082
<b>Male</b>	45	42		
<b>Female</b>	44	26		
<b>Comorbidity</b>				
<b>Diabetes mellitus</b>	22	5	2.556	0.016

<b>Chronic obstructive pulmonary diseases</b>	11	8	1.876	0.448
<b>Congestive heart failure</b>	11	7	1.161	0.867
<b>Chronic liver failure</b>	13	4	4.921	0.027
<b>Corticosteroid usage</b>	9	14	0.143	0.232
<b>Neutropenia</b>	6	3	1.657	0.550
<b>Malignancy</b>	29	15	1.134	0.450
<b>Chemotherapy</b>	16	5	3.145	0.035
<b>Invasive procedures</b>				
<b>Mechanical ventilation</b>	61	37	2.213	0.557
<b>Central catheterisation</b>	72	55	1.234	0.813
<b>Urinary catheterisation</b>	93	68	0.345	0.836
<b>medications used before to diagnosis</b>				
<b>Penicillin and derivatives</b>	28	13	2.986	0.356
<b>3rd generation cephalosporins</b>	30	21	1.066	0.742
<b>Fluoroquinolones</b>	21	3	3.513	0.210
<b>Aminoglycosides</b>	5	1	2.426	0.346
<b>Carbapenems</b>	47	29	0.432	0.629
<b>Colistin</b>	2	6	0.654	0.286

The value of  $p < 0.05$  was set as the significance threshold (in italics) CI confidence interval

### 3.3 Antimicrobial susceptibility of invasive MDR *A. baumannii* isolates:

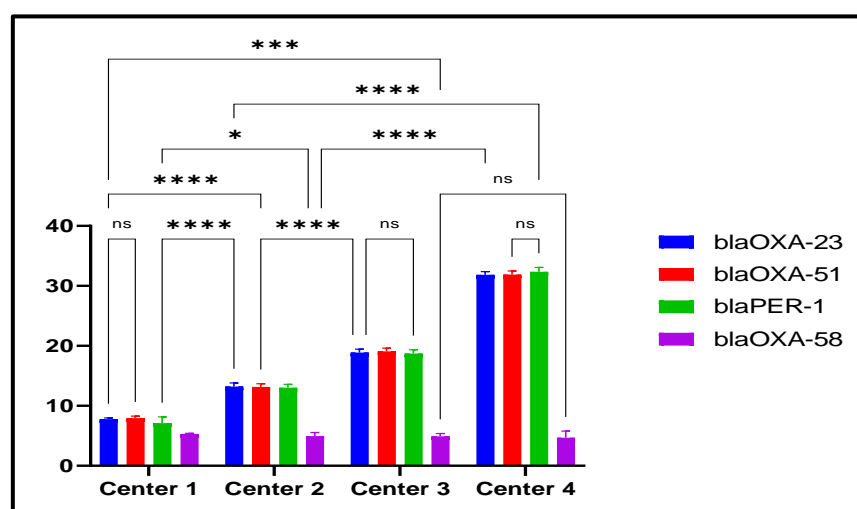
Table 3 details the antimicrobial susceptibility profiles of the 172 MDR *Acinetobacter baumannii* isolates collected from patients in the ICU. All isolates exhibited high levels of resistance to the tested antibiotics, with resistance rates exceeding 90% for amikacin, ampicillin-sulbactam, ceftazidime, ciprofloxacin, and imipenem. Colistin demonstrated the lowest resistance rate at 2.2%, while tigecycline resistance was observed in 4.7% of isolates. The MIC ranges indicate widespread multidrug resistance, with many isolates displaying high MIC values ( $\geq 256$  mg/L) for multiple antibiotics. These findings highlight the alarming prevalence of extensively drug-resistant *A. baumannii* strains in the studied ICU settings, emphasizing the urgent need for effective infection control measures and the development of novel therapeutic strategies.

**Table 3. The sensitivity of invasive MDR *A. baumannii* isolates from intensive care units to antibiotics (n = 172).**

antimicrobial substance	MIC50 in milligrams per liter	MIC90 in milligrams per liter	MIC range (milligrams/liter)	Resistance as a percentage
Amikacin	$\geq 244$	$\geq 247$	1 to $\geq 256$	91.8
Ampicillin–sulbactam	243	$\geq 221$	32 to $\geq 256$	98.4
Ceftazidime	256	$\geq 236$	16 to $\geq 256$	98.4
Ciprofloxacin	149	$\geq 286$	10 to $\geq 246$	100
Imipenem	54	178	5 to $\geq 246$	99.4
Colistin	0.8	1.0	0.25–64	2.2
Tigecycline	1.0	3.0	0.01–3	4.7

### 3.4 Resistance genes according to centers:

Figure 1 illustrates the frequency of four key antibiotic resistance genes (*bla*OXA-23, *bla*OXA-51, *bla*PER-1, and *bla*OXA-58) among MDR *Acinetobacter baumannii* isolates across the four participating medical centers. *bla*OXA-23 was the most prevalent resistance gene detected in all centers, with significantly higher frequencies observed in Center 1 and Center 2 compared to Center 3 and Center 4. *bla*OXA-51 was also found in all centers, but with no significant difference in frequency between centers. *bla*PER-1 demonstrated a significant difference in frequency, being present only in Center 1 and Center 2. Lastly, *bla*OXA-58 was found at a relatively low frequency in Center 1 and Center 2, with no detection in Center 3 and Center 4. These results suggest a possible variation in the distribution of resistance genes among *A. baumannii* isolates across different healthcare facilities, with *bla*OXA-23 being the dominant resistance mechanism in this study population.

**Figure 1. The resistance gene frequency as reported by centers.**



#### 4. Discussion

This work aimed at describing the epidemiological characteristics and all factors potentially related with the invasive MDR *A. baumannii* in a set of 164 ICU patients. Still, mortality was slightly higher (56. 4%) among surgical ICMinating that the majority of the patients were male (51. 6%) and admitted to surgical ICUs (44. 2%). All of the patients (100%) were noted to have had either an indwelling Foley catheter or terminal urethral catheters at some point of their hospital stay and 97. 4% of the patients had urinary catheters on the day of death. About 73. 4% had central catheters, while 67. 3% had mechanical ventilation. Such observations are in sync with prior studies predicting the high incidence of MDR *A. baumannii* in ICU; and the invasion procedure raising the odds of the disease (Alotaibi et al., 2021). Higher mortality and frequent use of invasive procedures in this study might be explained elevated disease severity and overall acuity of the ICU patients who are at great risk for opportunistic pathogens including MDR *A. baumannii* (Bestilleiro et al., 2021; Isigi et al., 2023). Furthermore, the misuse of broad-spectrum antibiotics in ICUs in this study increases the selection and emergence of antibiotic resistant organisms – MDR complicating treatment and increasing mortality (Bagińska et al., 2021; Kyriakidis et al., 2021). Therefore, it is only imperative that adequate infection prevention and control interventions, appropriate use of antibiotics, and research on production of new drugs or effective therapeutic approaches to managing invasive MDR *A. baumannii* infections shall be given utmost consideration.

This research aimed at determining certain factors that would help establish mortality risk in 164 patients with invasive MDR *Acinetobacter baumannii* infection. Age more than 65 years, diabetes mellitus, chronic liver failure and prior chemotherapy also proved to be statically significant for increased mortality rate. These findings are in concordance with the past studies, which have reported the high-risk patients, suffering from comorbidities, or are elderly, to have worse *A. baumannii* outcomes (Arvaniti et al., 2022). This may remain attributed to the fact that the immunity of such patients is suppressed, thus making them vulnerable to infection and complications (Alrahmany et al., 2022). Moreover the use of chemotherapy reduces immunity and since the study targeted patients with cancer who had used chemotherapy this could be the reason as to why its mortality rate was high (Sharma et al., 2024). On the other hand, no correlation between mortality and gender, other diseases or invasive interventions were established, which might be attributed to the small number of cases available or the multifactorial nature of patient's mortality. Based on the findings of this study, the identified independent predictors of mortality in patients with invasive MDR *A. baumannii* infections

include; Older age, Diabetes Mellitus, Chronic Liver Failure and prior Chemotherapy treatment.

This work retrospectively assessed the antimicrobial resistance pattern of 172 strains of invasive MDR *Acinetobacter baumannii* from ICU patients. The findings are quite startling, with overall resistance to amikacin, Ampicillin sulbactam, Ceftazidime, Ciprofloxacin and Imipenem all above 90% thus pointing to multidrug resistance. MHI: Colistin had the least resistance (2.2%) tigecycline had a higher resistance of 4.7% resistance. These findings are paralleled by other works indicating the rise of resistance frequencies of *A. baumannii* to essential antibiotics, including carbapenems (Müller et al., 2023). This is especially due to the wrong practice of using and or abusing antibiotics in health sectors which results to selective pressure that leads to the development of resistant strains (Kyriakidis et al., 2021). The high MIC values observed for multiple antibiotics, often exceeding 256 mg/L, further highlight the severity of this resistance problem and the limited therapeutic options available (Chen et al., 2023). In conclusion, this study underscores the pressing need for effective infection control measures, judicious antibiotic stewardship programs, and the development of novel therapeutic strategies to address the growing threat of extensively drug-resistant *A. baumannii* in healthcare settings.

The purpose of this study was to determine how often the four major antibiotic resistance genes namely, blaOXA-23, blaOXA-51, blaPER-1, and blaOXA-58 were detected in MDR *A. baumannii* isolates from four different medical centres in Iraq. The results presented in Fig. 1 show that the highest prevalence of the gene was observed for blaOXA-23 that was identified in all centers with higher rates in Center 1 and Center 2 compared to Center 3 and Center 4. Another gene, blaOXA-51, was common in all centers, though with only slight differences between them. blaPER-1 – was identified only in the isolates originating from Center 1 and Center 2, and blaOXA-58 was found at a low rate in Center 1 and Center 2 only. These results can be comparable with other research that has described the emergence the blaOXA-23 gene as the most common Carbapenem resistance factor found in *A. baumannii* (Kafshnouchi et al., 2022). This is perhaps attributable to the noticing factor through horizontal gene transfer brought about by mobile genetic part such as plasmids (Wang et al., 2021). It seems that the variation, which was observed in different centers related to the frequency of resistance genes could be due to the differences in the usage of antibiotics, measures of infection control and the type of *A. baumannii* strains prevalent in those centers (Chakravarty, 2020). In conclusion, this study stresses the need to monitor resistance genes in *A. baumannii* practically on a day to day

basis as well as formulate good infection control measures in order to minimize on the spread of MDR *A. baumannii*.

## **5. Conclusion**

This work that aimed at assessing the occurrence of MDR *A. baumannii* isolated from Iraqi ICUs unveiled high rates of such infections as well high mortality rates associated with them. Most patients were male, in surgical ICUs, and who had invasive procedures reflecting the high risk of the population and a role played by HAIs. Age of 60 years or above, diabetes mellitus, chronic liver failure, and chemotherapy before diagnosis of hepatocellular carcinoma was identified as independent predictors of mortality. Worryingly, all the isolates were resistant to the majority of the antibiotics, which was accompanied by the prevailing of the blaOXA-23 gene. This gene must be spread potentially via mobile genetic elements, and therefore absence of proper infection control measures and responsible use of antibiotics may lead to the emergence of these extremely resistant strains.

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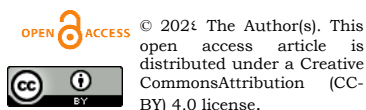


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## AL-Diwaniyah River Water Quality And Impact On Algae Diversity

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Haneen saad Jabbar <sup>2</sup>



### Abstract

Algae were the primary producers in freshwater ecosystems, playing a vital role in maintaining the overall health and balance of river systems. The diversity of algae communities reflects the quality of river water, with changes in algae composition serving as a reliable indicator of water quality. This study was conducted to determine the diversity of algae in the Diwaniyah River. The study included the physicochemical properties of the water and some heavy metals. Several types of algae were identified in the study areas, and the highest number of algae were found in the site 2 and site 3. The spread of algae is affected by influenced by water pH, temperature, electrical conductivity, as well as the availability of NO<sub>3</sub> and PO<sub>4</sub> compounds and food distribution sources.

**Keywords:** *Heavy Elements, Sewage, Phosphate ,River, Cyanophyceae.*

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## Introduction

The most significant water resource in the globe, and in Iraq specifically, is its rivers (Al-Ansari & Knutsson, 2014). Algae are found in most aquatic environments (Ghorbani, 2014), as they are considered their normal habitat, as they are found in all types of running and still water (Juo & Wilding, 2019). They are considered one of the most important living organisms in the aquatic environment due to their essential role in the food chain (Shalaby, 2011). Although algae are the primary producer in the aquatic environment, they cause important environmental problems (Rai *et al.*, 2000). Sewage water contributes to the growth of algae in water bodies and rivers, as well as the excessive use of fertilizers in agricultural practices. (Singh & Dhar, 2006). It has been found that the increase in algae growth due to nutritional enrichment in natural waters, especially those that receive large quantities of household and industrial waste (Human *et al.*, 2018), causes a decrease in oxygen concentration and the corruption of water resources (Buriyo *et al.*, 2024). Some algae are used as indicators of water quality (Shekhar *et al.*, 2008), biological productivity, and the extent of pollution by human and industrial waste (Pourafasyabi & Ramezanpour, 2014). Some of them thrive in organically polluted water, such as blue-green algae and euglena algae, while others are sensitive to changes in nutrient levels, light, and temperature resulting from pollution (Ibrahim *et al.*, 2022). Ensuring the preservation and efficient utilization of water resources is deemed crucial for all nations to achieve the global sustainable development objectives (Makanda *et al.*, 2022). They include nutrients like N, P, and K that lead to eutrophication and algae blooms in water resources (Wurtsbaugh *et al.*, 2019). The two most prevalent forms of freshwater algae in aquatic environments are benthic and planktonic (Sheath & Wehr, 2015). This change in properties is caused by the presence of pollutants in the water, which greatly affects the composition and density of the phytoplankton community by changing the conditions suitable for their growth or by containing heavy elements (Hassan *et al.*, 2008). Temperature is one of the most important environmental factors that control the growth and dominance of algae (Wang *et al.*, 2024), especially blue-green algae. Also, the pH is essential for the growth and diversity of algae in river water (Salman *et al.*, 2013). The current study aims to accurately identify the algae in the Diwaniyah River in addition to the chemical and physical changes in the water during the winter, summer and winter seasons, finally Some heavy metal in the research locations were measured.

## Materials and method

AL-Diwaniyah is one of the cities in southern Iraq and the Middle Euphrates region With geographical coordinates 31.9641427, 44.9066503. AL-Diwaniyah is located in a desert climate characterized by high temperatures and dryness in the summer and moderate in the winter. Rainfall is variable and scarce (less than 60 mm). A branch of the Euphrates River known as Shatt al-Diwaniyah passes through it, about 180 kilometers from Baghdad. The length of the Diwaniyah River is 121 km, including the Diwaniyah Governorate, and its width is between 20 and 25 meters, and its depth is between two and four meters.

## sampling and Analyzing experimental data

Samples for the qualitative study were collected using a 30-millimeter algae net according to the method(Vollen –weider ,1974). In general, three stations with a depth of 25 cm underwater were used to collected water samples over the winter2023, spring2023, and summer2023 months .The average months were calculated for the studied areas . The samples were taken in 2 L polyethylene containers and immediately transferred to the laboratory at 4C°. water temperature, pH, EC was measure .A spectrophotometer test was used to assess NO<sub>3</sub> and PO<sub>4</sub>(Adams,2017). Algae were identified by passing samples through a 0.45 µm filter wash with 1 ml of distilled water, Next, algae were counted using a light microscope (magnification 10). The samples were prepared according to the method of( Willén, 1976),Slides were prepared for counting the number of diatom cells according to the method(Hadi, 1984), Fig1.

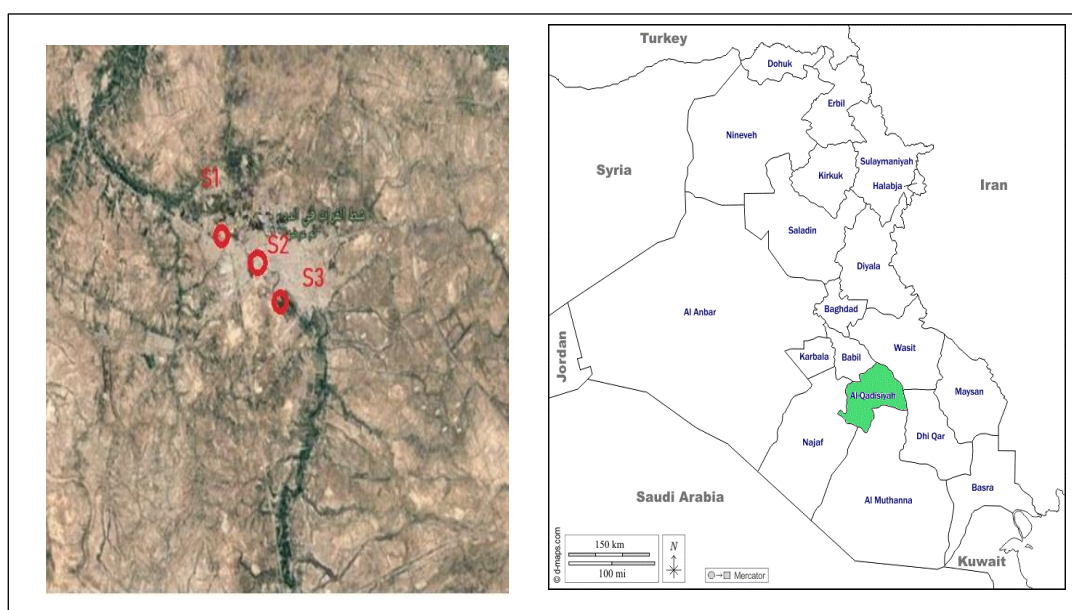


Figure 1. AL-Diwaniyah map and collection sites



## Result and Discussion

Algae are commonly found in freshwater habitats such lakes, rivers, dams, and reservoirs with less polluted water(Stevenson,2014). In many instances, it has been seen that municipalities and industrial enterprises are also discharging untreated factory effluent into rivers, ponds, and other bodies of water, despite the fact that they are taking necessary action on this issue(Kligerman & Bouwer ,2015). A significant loss of the nutritional qualities of soils and water resources is being caused by the discharge of untreated effluents from municipal, industrial, urban runoff, and agricultural sites, which is resulting in algae blooms(Tariq & Mushtaq,2023).

Table 1. shows the numbers of algae species identified in study sites of the Diwaniyah River. The highest value of algae was in the site 3 was(168)while(١٤٨) in site1 .Algae blooms are caused by an abundance of sunshine, high temperatures, shallow, slowly moving water, and abundant nutrients from sewage and fertilizers(Burford *et al* .,2019).Algae growth, which is influenced by competition between various algae species , temperature , predation in the food chain, the level of pollution, and the water's flow characteristics, might be one explanation for variations in the quantity of algae found(Singh & Singh,2015). Natural mechanisms including circulation, upwelling relaxation, and river movement, as well as human loadings that cause eutrophication, are the two main causes of these species' blooms(Sellner *et al.*,2003). Because AL-Diwaniyah is located in southern Iraq, it is characterized by high temperatures in the summer(Hussian *et al.*, 2008) , the distribution of aquatic creatures, and their existence were all impacted by the temperature of the air and water(Merhoon,2017).

The water temperature ranged from(16.3- 30.1 C°), Numerous environmental factors can influence the temperature of water. These components include turbidity, stream confluence, heat transfer from the atmosphere, and sunlight/solar radiation(John *et al* .,2005). The pH values ranged between( 7.5 -7.9), the AL-Diwaniyah river water tends to be slightly alkaline, which falls within the international standards for natural water(AL-Mayali, 2014). The highest average of electrical conductivity was at site 3, which reached(2401.2  $\mu$ S/cm) The electrical conductivity of water depends on the temperature and the concentration of ions and dissolved salts in the water additionally sewage water discharged into the river(McCleskey *et al* .,2011), The highest average of water turbidity was(31.56) in site 3, The river's turbidity in the area is high due to the increase in sediment, the fact that it is a residential area, and the presence of sewage, the Mud and fine sand are examples of organic and non-organic materials that are suspended and dissolved and generate turbidity(Azis *et al* .,2015) .

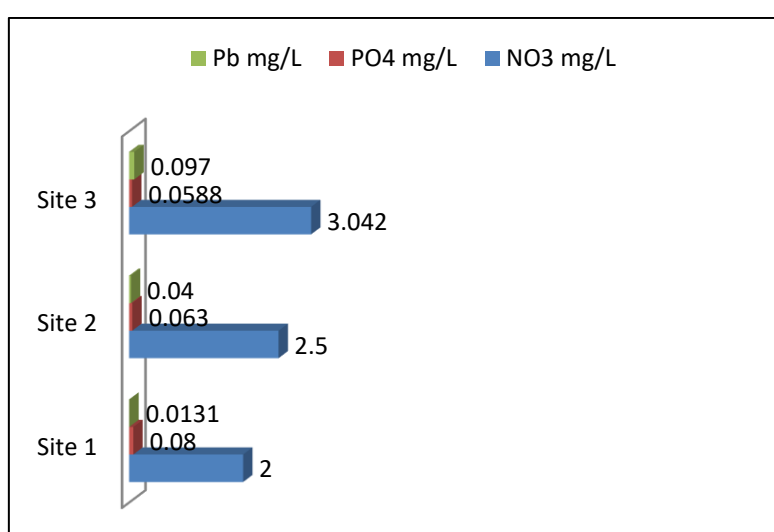
**Table 1. Algae species identified in the river during the winter, spring, and summer**

Type of algae	Species	Site 1	Site 2	Site 3
<b>Cyanophyceae</b>	Croococcus limneticus	9	16	20
	Oscillartoria tennus agarah	3	12	27
<b>Eugleophyceae</b>	Euglena acuse	2	4	7
	Euglena dangata	4	8	11
<b>Chloropyceae</b>	Chlorella vulgaris	19	24	37
	Pediastrum simplex	13	20	27
<b>Pennale</b>	Cocconeis planctula	9	12	22
	Datoma vulgar	15	11	17
<b>Total</b>		74	107	168

**Table 2. Physiochemical Parameters in the area site**

Parameters	Site 1	Site 2	Site 3
<b>Temp.water C°</b>	Average	Average	Average
	16.3.	23.1	30.1
	SD± variance	SD± variance	SD± variance
	8.188±67.05	13.297±176.28	17.398±302.713
<b>PH</b>	Average	Average	Average
	7.5	7.6	7.9
	SD± variance	SD± variance	SD± variance
	0.6782±0.046	0.2449±0.06	0.44022±0.1938
<b>EC µS/cm</b>	Average	Average	Average
	2266.8	1345.9	2401.2
	SD± variance	SD± variance	SD± variance
	1415.6±2003938	102.154±10435.46	1631.3±2661145
<b>Tru.NTU</b>	Average	Average	Average
	21.4	31.56	23.8
	SD± variance	SD± variance	SD± variance
	1.2884±1.686	7.309±53.426	0.5621±0.316

The current study showed that the highest value of  $\text{NO}_3$  was (3.042 mg/l) at the site3, also the highest concentration of  $\text{PO}_4$  was found in the site1,2 respectively (0.08, 0.063 mg/l) fig 2. The presence of phosphate as a result of the use of fertilizers due to the presence of plant nurseries and a residential area (Chalker-Scott, 2023), in addition to its presence in sewage (Houhou et al., 2009). The concentration of  $\text{NO}_3$  and phosphate is within the standards of Iraqi river water (Aljanabi et al., 2023). For heavy materials, the highest concentration of lead was (0.097 mg/l) found in site 3. In addition to population activities like the release of untreated sewage and industrial water into the water or industrial, chemical, and agricultural pollution in all its forms, heavy elements can enter the river environment naturally through rock melting, soil exposure to water erosion, erosion, dust, etc (Akoto et al., 2008).



**Figure 2. chemical parameters for Study areas( pb, phosphate ,nitrate mg/l)**

## Conclusions

The present study clarifies the first site has a low percentage of algae compared to the second and third sites. water characteristics affected the growth and numbers of algae, in addition to the presence of sewage discharge, which helped the algae to flourish. Concentrations of nitrate and phosphate were among the determinants in Iraqi water. When investigating heavy metals, lead was found in a low concentration, i.e. within the limits of Iraqi water.

## Acknowledgement

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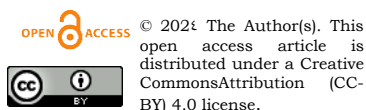
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## The Effects Of Sewage Water Upon The Fish Growth In Al-Hamza River

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### Abstract

Fish plays an important role as a healthy food source because its contains a lot of nutrients required for growth and better human health, fish needs clean or at least water have little pollutants to growth healthy in the river. This paper studying the impact of four heavy metals ( Cu, pb , and Iron or cadmium ) in sewage water upon fish growth, the type of fish have been chosen is Carp ( Cyprinus Carpio). The study including the physicochemical properties of the water and four heavy metals, samples collected during June-2024 , many heavy metals observed in this study four of them have been chose ( Cu, pb , cadmium and Iron ) the current study revealed that the growth of fish is influenced by the following parameters: water pH, temperature, turbidity , as well as the availability of nitrogen and phosphate compounds and food distribution sources. The study showed that fish in first station were active and healthy due to disappear of sewage water and the river pass throw village in first station, but the second station the fish were weak and smaller due to the presence of an untreated sewage network that was dumped into the river, in addition to a place for washing cars, but the last station fish were better than the second station but not like the first station, the distance between each station is 5 KM .**aim of study** shown the fish growth in Al- Hamza River including physicochemical parameters measurement in the study stations , finally four heavy metal in the study lab were measured.

**Keywords:** *Water quality, Al-Hamza River, Physicochemical Properties , Heavy Metals.*

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## Introduction

Water pollution affects the ecosystem in general and directly and causes many health problems, including poisoning, cancers, and others. It also harms aquatic life, reduces biodiversity and disturbs sensitive ecosystems (1). The sources and causes of water pollution are due to human activities. Industrial wastewater, which is discharged into waterways and contains chemicals, heavy metals, and other pollutants. The first of these pollutants, then comes agricultural liquid waste (2). One significant farmed species is the common carp (*Cyprinus carpio*). Due to their great size and long lifetime, common carp are the dominant species in lakes and wetlands. Common carp is often utilized in genotoxicity studies and is generally regarded as one of the main foods consumed by Iraqis. (3) Agriculture uses pesticides, fertilizers and other chemicals. These materials are transported to waterways through irrigation or rain. Which leads to the contamination of potable water sources and causes damage to aquatic ecosystems. Pathogenic bacteria present in animal waste resulting from livestock farming operations can contribute to water pollution by contaminating the water supply (4). Heavy metals, oils and grease, urban runoff is a significant contributor to water pollution because rainwater can collect these materials as it travels across paved surfaces and into waterways. In addition, untreated effluents due to septic system failure or wastewater treatment plants can expose rivers and streams to pathogens and bacteria, posing a threat to public health (5). Fish wealth is very important globally and locally, as it provides the country's economy with great wealth, in addition to providing humans with protein, oils, and vitamins that are important for their health, and using some fish waste as feed for domestic animals such as chickens and poultry (6). In Iraq, fish are considered the most abundant vertebrate in the aquatic environment as a result of the presence of the Tigris and Euphrates rivers and their tributaries. There are distinctive local species, the most important of which are Barbus, Himri, Gattan, carp, and others, which depend for their nutrition on aquatic production (7). Fish are considered one of the most important biological monitoring devices in water to estimate the level of metal pollution. They provide many specific advantages in describing the natural characteristics of aquatic systems and in evaluating changes in the aquatic environment. Fish are located at the end of the aquatic food chain, and metals may accumulate and be transferred to humans through food, causing many diseases (8). Many researchers have studied fish as indicators of environmental pollution with heavy metals, including (9), who studied the accumulation of metals in the muscles of several types of fish in the Sunniyah River, Iraq. (10) also explained the physiological effects on the reproductive system of carp fish after being exposed to heavy



elements in the Kour River in Iran . (11) explained that heavy metals found in aquatic systems polluted with sewage waste affect all living activities in fish.

## **Materials And Methods**

### **Sample Collections:**

The samples were directly taken from the Al-Hamza river, using dry , clean 1-liter plastic bottles. Before starting to take the samples, the bottles had been washed properly to avoid contamination. Sampling was done in three different stations along the river. Each sampling point was 5 km apart. The sampling was done 30 cm away from the bed of the river and parallel to the flow of the river at each station. Two samples at each point were collected to ensure representativeness of the data.

### **Physical Parameters Measurement:**

**Temperature (T):** The temperature was measured in the field using a thermometer. The temperature undergoes seasonal and changes that might affect the quality of the water.

**pH:** A pH meter was used to measure whether the water was acidic or alkaline.

**Total Hardness (TH) and Electrical Conductivity (EC):** TH and EC were determined to find out the content of minerals and salinity of river water,

### **Laboratory Analysis :**

The samples were then taken to the laboratory for chemical analysis. The analyses included four heavy metals, which contaminate field water. The samples were directly obtained from the river using a dry and clean plastic bottles. The bottles were cleaned properly before filling the samples at each station. The bottles were closed and labelled after sampling properly. The two samples were collected at each station. The river was divided into three points at an interval of 5 km and the samples were tested locally for both physical and chemical properties. Temperature, pH, TH, and EC were measured for the physical parameters, which may alter with a climatic change with time. The samples were then transported to the laboratory for chemical analysis. Chemical parameters that been tested were lead ion, cadmium ion, iron ion and copper ion.

## Results And Discussion

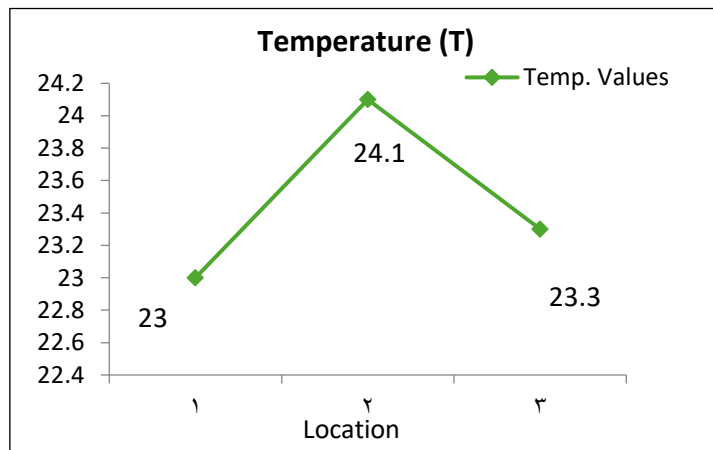
Physiochemical properties of 4 parameters were measured during the sampling that collected of present study period in 3 different stations of Al-Hamza river. The physical parameters included a range of locational measurements that provide the first indications of the quality of river water., as shown in Table 1. All these measurements were done locally with instruments such as a thermometer, a pH meter, and a TH and EC instrument for temperature, pH, total hardness, and electrical conductivity, respectively.

**Table 1. Physical parameters range and reading chemical parameters that been tested were lead ion, cadmium ion, iron ion and copper ion.**

Parameters	Range	Between
PH( on location)	7.78	7.4 – 8.17
E.C.	15.40	14.80 – 16.00
T.H.	14.5	13 - 16
Temperature	23.5	23 – 24.1

### Water Physical Parameters:

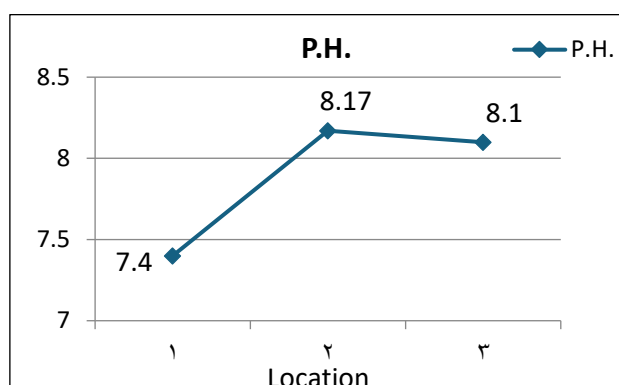
**Temperature (T):** Even though river temperatures are frequently most sensitive to atmospheric conditions, changes in streamflow also have a significant effect on water temperatures, particularly during warm, dry periods with low river flows.. Consequently, when projecting the effects of future climate change on the temperature of river water, the combined effects of atmospheric warming and variations in river flow should be considered. [12] Temperature is one of the parameters that determines most of the characteristics of the water environment and controls its activities. Results indicated that temperature values varied at all the selected locations from 23°C to 24.1°C, as shown in Figure 1 and Table 1.



**Figure 1. Temperature's values during collection samples ( on June – 2024 )**

The temperature is 23°C at location 1 and increases to 24.1°C at location 2 and dropped back at 23.1°C at location 3.. The temperature at locations 1 and 3 is almost the same at 23°C, showing no change. These slight variations across the sample records show that the samples were collected throughout brief time intervals. Additionally, it is demonstrated that the temperatures of the rivers were consistent, with seasonal, temporal, and local fluctuations.

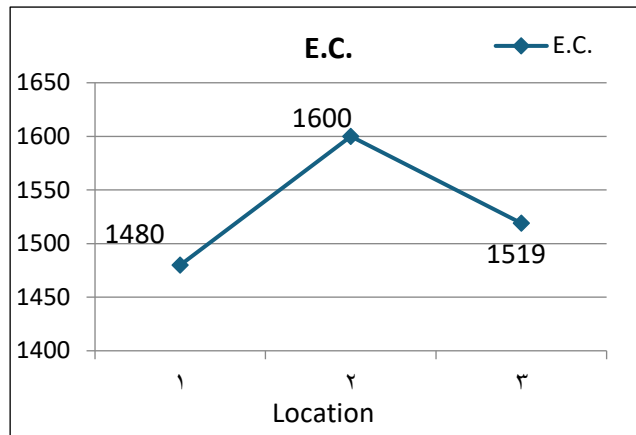
**pH Value:** The power of hydrogen, or more specifically, the power of hydrogen ion concentration, can be thought of as being represented by pH. Most natural water is alkaline due to the presence of bicarbonates and carbonates formed by the dissolution of atmospheric carbon dioxide. The pH of water can change dramatically due to the common metabolic processes that take place there..[12] Figure 2 illustrates that the records of the pH are almost similar in value across all locations while ranging from 7.4°C – 8.8°C as indicated on table 1.



**Figure 2. pH values**

As shown in figure 2, the pH level is 7.4, which is slightly acidic to neutral at location 1 while at location 2, the pH level sharply increases to 8.17, indicating a basic (alkaline) environment. The pH level drops to 8.1 at location 3, still in the basic range but lower than at Location 2. There is an initial increase from location 1 to location 2 and a gradual decline with minor fluctuations from locations 3 through . The value never drops below 7, so all the locations are on the basic side of pH, except for location 1. The value of pH has an important role in adjusting biological functions, moderating microbial activities, controlling nutrient availability, and regulating chemical behaviour.

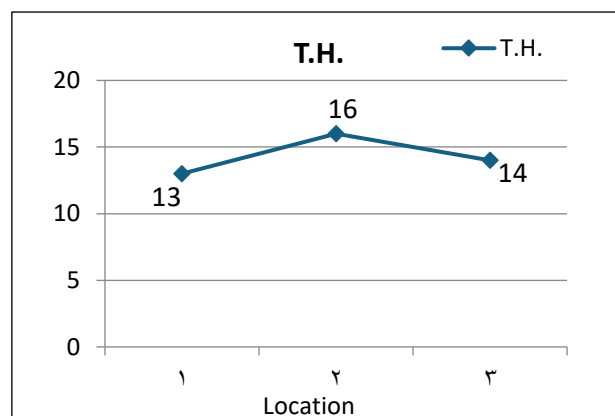
**Electrical Conductivity (EC):** The ability of water to carry current is known as electrical conductivity, and it is brought on by the presence of salt, acids, and bases known as electrolytes, which can produce cations and anions. The conductivity's magnitude can provide a reasonable estimate of the amount of dissolved solids because it is directly correlated with the presence of dissolve salts.. [13]



**Figure 3. Electrical Conductivity value**

Figure 3 shows the E.C. value is 1480 at location 1 while the value increases to 1600 at location 2. At Location 3, the E.C. value decreased to 1519, which is the highest point on the graph was in location 2, The general trend is an increase in E.C. from Location 1 to Location 2, a decrease to Location 3, thus more conductive; therefore, this may indicate more ions or different material composition. This decrease at Location 3 may further point to a change in material composition or environmental factors that affect conductivity. A high concentration of dissolved salts or ions is indicated by high E.C. values, which makes the findings of electrical conductivity measurements in a variety of domains related to material science, agriculture, and environmental monitoring promising. Fluctuations across locations and variations within a location over time demonstrate that circumstances, or even composition, may differ between locations, making some more conductive than others. [14]

**Total Hardness (TH):** Hardness is caused by divalent metallic ions, which can react with sops to create ppt. The main source of temporary hardness, also known as carbonate hardness, is the presence of calcium and magnesium carbonate and bicarbonates, which are removed by boiling. [13]



**Figure 4: Total Hardness value**



As shown in Figure 4, the T.H. value is 13 at location 1, which is the lowest value on the graph, while at location 2, the T.H. value increases to 16. The T.H. value decrease to 14 at location, the value of this indicator increased in the percentage of salinity from the first location. At other places, the value continued to rise for two reasons. The industrial areas or the sewage water from the abandoned settlements are the first causes. The second reason is because of natural processes like soil washing and dissolution caused by rain. [15]

### **Water Chemical Parameters:**

The right kind and quantity of acid is applied in order to analyze the components in water. Using the incorrect acid causes the metal to be lost from the sample or recover poorly. The concentration of acid must be determined by the expected concentration of the metal. Prior to sample collection, it is crucial to rinse the sample container with deionized water and wash it with acid. Metals may be lost through adsorption onto the container walls if the sample is not adequately acidified. To identify silver, use dark brown bottles or glass bottles that absorb light. Before usage, glass bottles and filtering equipment need to be acid washed ( 16,17). Water sample have been injected in Atomic absorption spectroscopy to determine the concentration of four heavy metals ( Cu, pb , Fe and Cd ) , the results show that the concentrations of Cu, Cd, Fe and pb are ( 0.50 , 0.06 , 2.78 and 2.45 )  $\mu\text{g/L}$  respectively in the first station, The results show that the rates of studied heavy elements of the dissolved phase were within the parameters of the Iraqi maintenance of the pollution of rivers and drinking water, and with (WHO),, but in the second station the concentrations of (Cu, Cd , Fe and pb ) are ( 0.7 , 0.15 , 3.6 and 3.1  $\mu\text{g/L}$  ) respectively, the results in second station were higher than the first station because the samples have been taken from the river close to sewage water pipe in the center of the city which means sewage water have high concentration of heavy metals which came from cleaner , soap and the others detergents. Finally in the third station the concentrations of ( Cu, Cd, Fe and pb ) were (0.56 , 0.064 , 2.9 and 2.61 )  $\mu\text{g/L}$ , the results in the third station show that the concentration of heavy metals were less than the second station.

### **Conclusion And Recommendations**

It is this physicochemical assessment that becomes the great vista through which the suitability of al-hamza river for fish growth in Southern Iraq is viewed. Going through the results of this study show that, against basic water quality standards, the river was suitable for fish growth with localized differences in temperatures, pH, and mineral contents needing to be addressed to optimize the use for helping the fish to growth normally without any effects. The research work accordingly recommends continued monitoring and management practices in

dealing with emerging challenges towards the promotion of sustainable water use for fish growth and trying the best to treat the sewage water before release it to the river. The present study adds to the existing literature on methodologies for water quality assessment applicable to similar river systems. Additionally, it requires that communal responsibility and informed decision-making be integral components of water resource management.

Variations and risks detected make it possible to ensure, in the conditions of South Iraq, sustainable fish growth. Water quality can be preserved by halting urbanization and deforestation. We can find the solution through physical, chemical, and biological processes of wastewater treatment. Water conservation and water treatment can save water from being polluted. It can mitigate global warming and protect people from the harmful impacts of water pollution, including cholera, typhoid fever, skin infections, and diarrhea. Water bodies, plants, animals, and people will all stay healthy if the environment is kept clean, preventing these situations. Both individual and group efforts can help reduce water pollution. We can work together to reduce water pollution, clean up our rivers and oceans, and improve the quality of life on Earth. Therefore, in order to control water pollution, the government must implement stringent legislation and treatment technologies including aeration, water treatment plants, and sedimentation. Reducing the quantity of pesticides that end up in the water is another benefit of green agriculture. [18-22]

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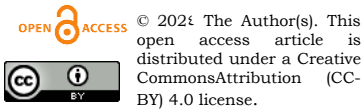
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## Critical Review Of Indoor Positioning Systems

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### Abstract

There has been a long-standing need for a robust Interior Positioning System that may be used in a variety of indoor settings. It is impressive how many different kinds of technologies, methods, and approaches are incorporated within IPS proposals. As a result of this variety and the absence of rigorous and verifiable evaluations, it is sometimes difficult to determine the genuine worth of most ideas. In order to have a full picture of the state of the art in indoor placement, this paper presents a meta-review that synthesizes numerous survey studies. The paper introduces the concept of IPS and the many technologies, strategies, and approaches that are used to implement it. The introduction is backed up by common ground discovered in the aforementioned studies, which are cited as sources. To that end, the meta-review provides a high-level overview of the current state of IPS and directs the reader to where they may learn more about each technology employed by IPS. Using citation counts as a metric, the meta-studies review shed light on the sheer volume and scholarly weight of published IPS proposals.

**Keywords:** *Location-Based Services, IPS, Meta-Review.*

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## I. Introduction

It's hard to conceive of living without the guidance provided by positioning systems. Our present way of life has been molded by GPS and other GNSS constellations. Many of us benefit from the evolution of Location-Based Services, which range from turn-by-turn directions on a vacation to targeted marketing. In addition to GNSS services, the proliferation of smartphones has helped propel LBS. More and more people throughout the world have access to smartphones and the Internet. Because of the high demand for mobile service and the near-constant proximity of most people to their cell phones, LBS has great potential. The importance of location in research across disciplines cannot be overstated. That's why there's so much money and interest in location-based services (LBS) and the technologies that support them on the international market. People in wealthy nations tend to spend little time outside. This trend will spread to other countries as the world as a whole advances. However, a low-cost, widely applicable technology that permits LBS optimized for interior settings is still lacking.

Numerous academic works, from undergraduate theses to PhD dissertations to well-funded international research initiatives, focus on the problem of indoor subject position estimate, most often in the context of mobile application users. There is an overwhelming amount of material published on the subject, but its distribution across media makes it difficult to conduct a comprehensive review. It's not easy to pin down the specific motivations for the proliferation of articles on the topic of indoor positioning. Possible explanations include: a widespread need to get academic work published; an explosion of new publication channels; and the low cost and low difficulty of building a basic positioning system. Industry's promise of rapid acceptance and billion-dollar investments for such a golden system; the system's elusive accuracy, low cost, and applicability to various indoor spaces at once. This work expands on (BLE)-based and WiFi-based fingerprinting for smartphones and adds to the existing body of knowledge by doing a meta-review of IPS research. Sixty-five different IPS topic surveys were included in the meta-analysis. Our meta-review takes a different approach than traditional reviews in that it examines IPS-related issues from the perspective of surveys rather than individual studies. Each explanation or definition represents the cumulative work of numerous reviewers. Brief descriptions of the processes and issues associated with WiFi-based as well as BLE-based IPS for smartphones are provided, as well as an introduction to IPS and a review of the technologies employed in IPS. When possible, references to the chosen surveys' works were included to back up the claims made in the description sections. This combined meta-review provides the reader with a snapshot of the present status of IPS as well as access

to in-depth information on the reader's preferred technologies. There is currently no survey that looks specifically at BLE-based indoor location or radio map enrichment techniques, as found by the meta-review. Therefore, this study provided concise summaries of proposals associated with these two fields. After the exposition, we discuss the plethora and scholarly importance of IPS works that have been published. Analyses were conducted according to how often each work had been cited, with an initial focus on the cited sources for chosen surveys and subsequent use of Google Scholar citation counts of specific publications. Most of the works cited in the surveys had little discernible effect on the IPS literature, as evidenced by the results. The three most important results of this study are, therefore:

- A compiled set of all the studies from IPS issued in the recent decade.
- Synopses of IPS tools that dealt with BLE-based indoor positioning and radio map enrichment techniques.
- To assess the present condition of IPS, we looked at how often certain polls referenced specific articles.

## **II. Positioning Indoor Systems**

Depending on their purpose, positioning systems can be either global or regional. Location estimates are now available anywhere in the world thanks to GPS. The abbreviation "GNSS" is used to refer to all of the many GPS systems that are now in use. The widespread accessibility, extensive coverage, and the availability of low-cost, small-footprint receivers have all contributed to the widespread adoption of GNSS-based positioning. Due to precision requirements and deteriorating satellite signals, it is not suitable for many situations and applications. When GNSS positioning cannot be used, local positioning systems are implemented instead. There is a wide range in the range or proximity of these positioning systems. Systems based on networks of pseudolites can cover very wide areas, while light-based systems are usually used to rooms. Within the scope of this work, we will be discussing Indoor Positioning Systems, a subset of LPPSs designed specifically to offer location estimates within structures. There is a significant risk that GNSS signals will be significantly impacted by the materials and construction methods used in new buildings. The degraded state of these signals by the time they reach receivers within buildings makes civil GNSS accuracy inadequate for many indoor uses. In addition, there are a lot of people and other hurdles to contend with in indoor settings. The signals are reflected and absorbed in unfavorable ways due to the interference from the obstructions. The huge efforts made over the past 20 years to develop new

solutions to IPS are understandable, given that people are spending more and more time indoors. Local positioning solutions would still be necessary for indoor LBS applications even if GNSS signals were not so heavily affected by buildings. The positioning precision offered by GNSS is insufficient for several uses. A millimeter-level accuracy may be necessary, for instance, for a robot to carry out precise activities that could not have their next step selected in an offline planning stage. Also, the scale of the intended environment may affect the precision needed for pedestrian applications. It has been found that people's willingness to accept less-than-precise location information is correlated with the amount of personal space they have. For use in a park or on a wide street, the normal accuracy of a smartphone's GNSS receptor is 6 m, which is more than adequate. Indoors, however, this distance may not be entirely accurate. Therefore, the ideal mean accuracy for an IPS would be between 0.5 m and 1 m for use in the vast majority of inside conditions as well as applications. When something is accurately located, there is a high degree of agreement or proximity between the estimated or measured location and the actual location of the subject or object at that time. This concept of precision is quite inclusive. Given the wide variety of available positioning systems, however, it is tricky to establish a more precise description or rely on a single statistic. While precision is essential, it is not the only factor considered when rating an IPS. IPSs are often evaluated and compared across a variety of criteria, including coverage, complexity, resilience, scalability, cost, privacy, and power consumption. The coverage of the technology behind an IPS is the area within which its signals can be received. Due to its excellent coverage, the IPS may be deployed over a wide region with a modest number of emitters. The complexity of an intrusion prevention system is measured by the time and effort needed for its development, implementation, or setup. When a system is robust, it can withstand stresses that are outside of its normal operating range. The scalability of a positioning system is measured by how well it works for a large amount of people in a sizable area. The term "cost" encompasses any expenditures made in order to acquire or set up the necessary infrastructure or positioning devices. When it comes to computers, privacy is all about setting up barriers so no personal data is gathered. Last but not least, the less energy needed, the better. When it comes to user devices, having a low load demand means less time spent charging.

### **III. About Ips Solutions**

Over the past two decades or more, researchers have produced a growing body of work in response to the rising demand for IPS. The abundance of references in recent survey research on IPS indicates a high volume of ideas during this time period. There are reviews dedicated to

IPS that cite more than 250 sources, and even more than 350! The majority of this paper's findings are based largely on 65 pieces of IPS-related survey literature released during 2016 and 2020. Fifty were featured in magazines and other periodicals. Not taken into account were studies like Aparicio et al. that simply made passing reference to indoor positioning techniques or whose content was not readily available online. The large volume of surveys has resulted in an increase in specialization. Some of them, however, have dealt with a wide variety of answers suitable for interior positioning. It is customary for these "generic" surveys to differ from their predecessors not only by proposing new taxonomies or discussing more than others about specific elements like specific applications or issues, but also by offering updates on the latest IPS solutions. Although the section on positional constraints in Yassin et al. is brief and only refers a few other papers, it is nonetheless useful. There's also a section on cooperative positioning as well as data fusion, which has some good examples but no definitive separation of terms. The work by Sakpere et al. is recent, covers nearly all methods, excludes no practical uses, provides an abundance of citations, and addresses the benefits and downsides of each technique. In their exhaustive review, Brena et al. differentiate between "passive" and "active" systems, classifying as passive those in which the infrastructure alone creates the signal utilized for locating. Basiri et al. conducts a literature study and survey of LBS ordinary users, LBS researchers, LBS market analysts, and LBS application developers to assess the current state of IPS research. Given that the applications and aims of IPS transcend well beyond the scholarly literature, a survey of this nature was necessary. We believe the most recent IPS poll to be that conducted by Zafari et al (2019). This survey is unique because of the emphasis it places on the Internet of Things (IoT) by establishing a connection between IoT and indoor positioning. There's also a section devoted to IPS programs and a rundown of the biggest problems with IPS and how to fix them. In contrast, those that focused on technology only examined solutions in that context. Maghdid et al. and Davidson & Piche, for instance, both described methods that may be implemented on mobile devices. In particular, the relatively new work of Davidson and Piche is outstanding for its conciseness, right weighting of explanations and references, and coverage of all significant aspects of IPS for smartphones. Readers interested in mobile app positioning should begin with Davidson and Piche. This "generic" poll, as well as others, do not agree on a uniform taxonomy for IPS. Common categorizations focus on the underlying technology. Which physical quantities the system is able to measure is then determined by the technology. The physical quantities are often referred to as the applied procedures, and they are also utilized for IPS classification. Position estimates can be derived from a wide variety of measurable values, using a wide variety of approaches on top of the technologies and procedures. In addition, the methods are typically categorized as range-based or range-free

depending on whether they estimate distances or angles to known landmarks. The following is a brief introduction to some of the most often utilized IPS technology and techniques. They are referenced frequently in the rest of this section and are covered in nearly all of the chosen surveys. Some overviews also provide context and examples for utilizing additional methods, such as Received Signal Phase (RSP), Roundtrip Time of Flight (RTF), or Channel State Information (CSI). Arrival Time (TOA). It is the receiver's recording of how long it took for a signal to travel from an emitter to reach it. Since the speed of the signal's propagation (sound, radio frequencies) across the transmission medium is known, it may be utilized to estimate the distance to each emitter (air). Arrival Time Variation (TDOA). It's a lot like The Legend of Zelda. It does this by comparing the relative delays experienced by signals coming from various sources. To calculate differences in distances to each emitter. Proportional Incidence of Arrival (AOA). It describes the slant at which the signal hits the detector. Then, a position fix is calculated using the angles. Power of the Received Signal (RSS). An emitter's signal strength is the metric by which its output is evaluated. Attenuation and interference can modify the linear relationship between signal strength and distance from the emitter. How the position is approximated is dependent on the method used to get the solution. Distances to signal emitters can be estimated using TOA, TDOA, and RSS. Lateration takes into account the estimated distances to a group of emitters and finds the position estimate that best fits the group. When three distances are employed, the term "trilateration" is applied, whereas when more than three are used, the term "multilateration" is used. The term "angulation" refers to the process of using the angles collected in AoA to calculate a likely fix on the target position. Lateration and angulation are both examples of range-based (or ranging) techniques because they rely on prior knowledge of the emitters' locations. The RSS method is also used for fingerprinting, also known as scene analysis, which is a range-free methodology widely used in intrusion prevention systems. There are two phases to the fingerprinting process. To characterize the signals in the target scenario as thoroughly as possible, the first stage, also known as the offline stage, involves collecting and storing data on the signal quantity of each detected emitter at various times and locations. The compiled set of information is known as a training database. The database can also be referred to as a radio map if the signals being measured are RF. Site surveys, war drives, making radio maps, and collecting training fingerprints are all terms for the same data collection technique. The second stage, often known as the online stage, involves estimating the position corresponding to newly acquired signal quantities by looking up the stored fingerprints most closely matching the new data. In addition to the foregoing techniques, there are two others that are equally as important that do not rely on measuring signals from an



emitter and are thus range-free methods: hop count and vision analysis. When a packet moves from one part of a network to the next, this transition is known as a hop. Distance estimates and position inference via a graph embedding issue are both possible after counting the number of hops from a set of known nodes. Vision analysis is the process of applying several computer vision techniques to images obtained by means of an imaging method. The analyses pick up on pertinent scene elements that can be used to estimate where things are in the scene or where the recording imaging device is situated. An additional useful categorization at this level is whether positioning is done with or without the use of any external devices. In the former, a positioning device measures or sends out a signal as an active participant in the positioning process. Typically, a smartphone or a tag is used as the positioning device because of their portability. The majority of surveys and IPS literature focus on device-based solutions. Device-free location typically takes the form of presence detection or radar-like technologies. One of the main drivers behind the expansion of LBS is the proliferation of smartphones, further illustrating the significance of the device-based vs. device-free divide. Some of these studies concentrate solely on IPS solutions for mobile devices, while others also cover device-free positioning. As even the most cutting-edge smartphones only have a small set of sensors, it's important to make a distinction between whether or not an IPS is suitable to smartphones. You can also categorize solutions based on whether or not they need to deploy specialized hardware and software; the former are known as infrastructure-based solutions, while the latter are known as infrastructure-free solutions. It is important to consider the underlying technology and its specifics when developing an IPS. Next, we'll look at the technologies that are typically used in IPS implementations. Each instance will include specifics on the strategies used and how they might be adapted for range-based versus range-free versus device-based versus device-free categorization.

In contrast to infrared IPS, which can be either device-based or device-free, Visible Light Communication (VLC) IPS appear as device-based solutions. The VLC-based IPS is predicated on the premise that LED illumination is becoming more widespread, and that LEDs can rapidly and imperceptibly change the intensity level. Once the information has been encoded, the intensity level switches are turned off. Multiplexing, either by frequency or time, is used in situations with many LED emitters. The receiver may have a camera for visual data or a photodiode array for measuring signal characteristics including RSS, TDOA, and AOA. Lateration, angulation, and fingerprinting are all examples of positioning methods that can be used for the former. The latter requires several images and supplementary gear like accelerometers to translate the coordinates of the LEDs in the image into coordinates of the

environment. Average precisions for VLC-based IPS are typically given in centimeters. Do and Yoo warn that it is important to approach the provided results with caution due to the wide variety of test scenarios and conditions used by each of these approaches. There are still obstacles to overcome, such as synchronizing the timing of the emitters and making them resistant to sunlight.

Light-based IPS, whether it be device-based or device-free, has also made use of infrared signals. The former is exemplified by the innovative Active Badge Location System, in which tags sent codes via infrared light and were read by a distributed system of sensors. For the latter, consider Passive Infrared solutions like thermopile arrays or infrared cameras for imaging. There appears to be no infrared-based IPS survey, and the number of proposals for such systems is minimal in comparison to other IPS technologies, which may be due to the LOS need of infrared-based solutions, as found through the research conducted for this work. The majority of the light-based approaches all share a common goal: the reuse of current LED lighting systems. Specifically, the consulted polls predicted that expanding VLC systems will eventually be utilized for locating in a manner analogous to that of WiFi. Light-based IPS used to be limited by the capabilities of smartphones, which led to outsourcing some computations. These capabilities have increased, making camera-based designs possible and moving focus to issues like camera power consumption, improving accuracy in bright daylight, and reducing false positives. On the other hand, camera-based solutions cannot match the precision of photodiode-based designs and work only in line-of-sight (LOS) environments. As a further downside, VLC systems are not as common as WiFi. Accordingly, it is sometimes accepted that light-based IPS are still in their formative stages. Zhuang et al. and Afzalan and Jazizadeh's surveys are recent enough to acquire general yet solid understanding of light-based IPS. Vision approaches are employed in camera-based IPS without the need for any additional lighting infrastructure beyond that already present in a typical modern building. Despite the fact that cameras are used as the primary sensory input for SLAM at the moment, it is important not to limit SLAM to vision-based approaches. Laser scanners, sonars, and odometric data from wheel encoders can all be used for SLAM. Markers, such as printed QR codes, are a simple and effective method for facilitating device-based solutions. If the markers are processed in a sequence of photos of the scene and perspective is utilized to modify the estimates, marker-based IPS may even be able to produce continuous estimates. Input from a single camera or a network of cameras can be used in visual odometry. One or more cameras can capture everything going on in every direction, or they might focus in on one specific area. Methods like feature tracking and optical flow are typically used to ascertain camera motion and subject velocity. Because of advances

in computer vision and the processing power available in robotics and mobile devices, such as in the uses of Google's ARcore, visual odometry has already surpassed the cost and accuracy of competing odometry solutions. Installing a number of cameras throughout the area of interest is a frequent practice for device-free solutions. When combined with information about the environment captured during the target scenario, the photos are used to determine who or what is being sought. The usage of computer vision techniques for locating objects is expected to grow. Vision-based simultaneous localization and mapping (SLAM) and visual odometry are two applications that have helped to popularize and will continue to popularize the use of computer vision to identify subject positions. Applications in this area have stimulated the growth of not only software methods, but also hardware innovations like depth cameras. On top of that, visual odometry has a lower drift than wheel encoders and less accurate Inertial Navigation Systems. Despite its focus on SLAM, the study provides essential background for delving into the use of computer vision techniques in positioning in the future (that is, in the year 2025). While it's true that you should read, additional survey works are needed on the subject. In such endeavors, device-free options may be investigated.

Solutions that rely on magnetic fields are categorized by Pasku et al. as either using the Earth's natural magnetic field, direct current (DC) artificial magnetic fields, or alternating current (AC) artificial magnetic fields. Other general surveys, like Zafari et al., don't differentiate between the two, while Brena et al. does differentiate between the two, but focuses on the solutions that rely solely on the Earth's magnetic field because they believe this is the approach followed by the majority of contemporary solutions. The fact that similar systems may be easily applied to smartphones and have claimed accuracies in the range of a few meters lends credence to Brena et al. decision. 's

Magnetic IPS deduce a position from fluctuations in the magnetic field's strength. The ambient magnetic field is prone to fluctuations due to steel buildings in the indoor scenario of interest, necessitating the establishment of a database with the recorded variations of the magnetic field intensity. The accumulated data is then used by a fingerprinting technique to derive approximate locations. Multiple studies cite Magicol as a prominent example of work employing this method. Earth-based IPS need more data collection work and often have worse accuracy than IPS that use artificially created magnetic fields. However, they are inexpensive, simple to implement, and can cover a wide operational range. Artificial field systems require coil-based devices, which are power-hungry and only work at short ranges, but can achieve accuracies of several millimeters. To the best of the author's knowledge, all IPS solutions including magnets are implemented on physical devices. Transmission and reception

components for IPS using artificially created magnetic fields must still be miniaturized, and power consumption must be decreased. Citing Pasku et al. From 2013 through 2016, Pasku et al. reported commercial systems focused mostly on producing artificial magnetic fields. Even though Pasku et al. provide a thorough general introduction and update on magnetic-based IPS, they focus more on IPS based on artificial magnetic fields than on those based on natural magnetic fields. To learn more about the prevalence of IPS using natural magnetic fields in cellphones, check out the brief overview provided by Davidson and Piche. An excellent overview of how the magnetic field of the Earth can be used in conjunction with IPS in cellphones can be found in He and Shin. This study presents for each factor relevant and recent (at the time) works, and describes how measurements are taken, databases are constructed, and positioning is carried out. The study is exhaustive and provides measurement ranges from many instruments.

Since IPS that make use of Earth's magnetic fields are common in IPS literature, and He and Shin review research mostly from before 2017, a new magnetic-based survey is suggested. Both academic and commercial projects that use Earth's magnetic fields alone, as well as those that use Earth's magnetic fields in conjunction with other technologies, should be updated and detailed in the survey. Application of Dead Reckoning (DR) to device-based IPS. Pedestrian Dead Reckoning refers to the version of this phenomenon that is directed against pedestrians (PDR). Dead Reckoning is the process of estimating the location of a target based on the object's known fix and the measured parameters that characterize its motion, such as its heading and speed. Common inertial sensors include accelerometers for sensing translations (providing the acceleration magnitude along each of the three axes), gyroscopes for sensing rotations (providing roll, pitch, and yaw measurements), and magnetometers (compasses) for providing orientation with respect to the Earth's magnetic poles. Most of these sensors and the computational power to run PDR are built into today's smartphones. Inertial Measurement Units, which are used to construct inertial sensors, have also been implemented in PDR projects (IMUs). Even occasional waist mounts have been observed, IMUs are typically attached to the feet or legs. Since the mechanics of the walking process and the foot provide re-calibrations at every step using the Zero-velocity UPdaTes (ZUPT) approach, the shoe-mounted setup has become the most popular. DR relies on filtering methods like (Extended or Unscented) Kalman Filtering and Particle Filter (PF) to aggregate data. It is common practice to use two methods to estimate the path or movement. The first method is used by what are known as inertial navigation systems (INSs), which are responsible for integrating the data from the various sensors. As for the second method, it's been implemented in what are known as Step and

Heading Systems (SHSs), which are able to identify and count both steps and their directions. Filters are used to incorporate additional inputs, such as maps and constraints, in order to increase the reliability of the final product. When new positions are not predicted too far away from the last fix, PDR's accuracy is high for its modest price, and it doesn't rely on any external references. The problem is that it is prone to drifts and errors that build up over time. Thus, PDR is typically employed in conjunction with other technologies that serve to prop up IPS and supply periodic estimations useful for resolving drifts.

In addition to its usage in interior navigation and position calculation, dead reckoning has found widespread application in outdoor environments. Systems that cannot provide extremely precise placement with high confidence for moving targets would almost surely benefit from DR. Similar to how PDR for IPS on smartphones can use corrections from ancillary technologies, this is also true for IPS on other devices. The smartphone's IMU sensors aren't as precise as other IMUs, thus the cumulative drift quickly becomes an issue. As evidenced in the rise of mHealth devices, however, smaller IMUs are advancing, which will reduce PDR's reliance on third-party solutions to drift issues. While Diaz et al survey [1] is up-to-date (2019), Wu et al work [2] provides a more current (2018) and thorough assessment of PDR that relies exclusively on inertial sensors. Reading Davidson and Piche is recommended to learn more about potential technology combinations for the specific example of IPS on smartphones. For a comprehensive and up-to-date review of step length estimate models, a vital component of many PDR systems, see Vezocnik and Juric's work.

UWB has gained widespread recognition as an IPS technology. All three UWB surveys used the same definition of ultra-wideband (UWB), which is defined by the United States Federal Communications Commission as RF transmissions with a bandwidth of more than 450 MHz (22% of the center carrier frequency). That high frequency range is associated with a prominent feature recognized by numerous works: UWB relies on the emission of very brief pulses, with a pulse width of 200 ps and a transmission strength of a few watts, at precisely timed intervals [84]. The weak signal prevents interference with wireless networks like Bluetooth Low Energy (BLE). Due to the extremely brief pulse modulation, UWB is essentially immune to multipath problems. The NLOS routes are discovered after the primary pulse detection because the inter-pulse duration is long enough to execute multipath resolution without any uncertainty. The UWB's ability to penetrate obstacles is much greater than that of WiFi and BLE, making LOS situations less of a concern for it. In addition, it uses less power than rival WLAN standards like Bluetooth and WiFi. To use a UWB device for positioning, tags must be set up. A variety of sizes and shapes of tags, as well as mounting or wearing



locations on the positioning subject (e.g., on the feet or the head), have been recorded for UWB emitters in either fixed or mobile configurations. UWB placement can be achieved by RSS, ToA, AoA, or TDoA methods, depending on the specifics of the tags' implementation. Therefore, fingerprinting, lateration, or angulation are the documented methods employed for placement. Radio map development for fingerprinting is the least used UWB method because of the work involved. UWB is appealing for many applications because of the low stated accuracies (usually below 40 cm ), provided that the UWB tags are affordable for those uses. However, scaling is a major problem because of UWB's expensive equipment and short nominal range.

The ability of ultra-wideband (UWB) signals to pass through solid objects makes them a promising candidate for device-free location based on the radar concept. A subject's presence in a room with UWB emitters and receivers causes reflections of the signals, which can then be utilized to estimate the subject's position using the TOA and TDOA methods. Wi-Fi, abbreviated as Wi-Fi, is the Wireless Local Area Network (WLAN) technology that conforms to IEEE standard 802.11. Due to WiFi being the standard method for establishing a WLAN, WiFi-based positioning is sometimes referred to as WLAN positioning. All of the included polls highlight WiFi because it is a technology that helps IPS. Furthermore, to the author's knowledge, it is cited in all existing IPS proposals. WiFi uses the 2.4 GHz and 5.0 GHz bands, with 20 MHz, 40 MHz, and 80 MHz as its standard channel widths. Although signals in the 2.5 GHz range have a greater range, those in the 6.0 GHz range have wider channels and are less susceptible to quick fading. Use of CSI, ToF, and AoA methods in reported works is widespread. However, RSS is the most common method used because it can be used with many current cell phones. Wi-Fi-based IPSs are widely used, however they face significant difficulties because of the changes that indoor environments impose on RF signals. WiFi-based ideas employ the existing WiFi networks to accomplish low-cost solutions, although WiFi networks are often deployed for communication purposes, not positioning. If the AP locations are known, a model-based technique, also known as lateration based on a propagation model, can be used by WiFi RSS positioning solutions. Nonetheless, fingerprinting has surpassed lateration as the preferred method due to its superior accuracy. WiFi-based IPS are predominantly device-based solutions because they are directly applicable to various smartphones. In addition, there are device-free systems, which often utilize RSS or CSI to ascertain the location of the entities once initial anomaly or motion detection has been performed. Techniques including fingerprinting, link-based systems, and radio tomography imaging (TMI) are used. WiFi intrusion prevention system (IPS) surveys and solutions have

evolved throughout time to take into account and plan for known difficulties and upcoming upgrade measures. While WiFi-based intrusion prevention systems (IPS) have gained widespread acceptance, it is often overlooked that their typical accuracy has not increased in recent years. Methods of foresight like CSI have not yet shown to be particularly fruitful. WiFi intrusion prevention systems, especially those based on fingerprinting, have become increasingly popular due to their low cost and simplicity of implementation. However, recent updates to Android smartphones could diminish the platform's appeal. Khalajmehrabadi et al. is a great resource to check out because it provides a concise overview of the most relevant works up to the time of its release. Khalajmehrabadi et al.'s study is as thorough as He and Chan's, plus it's more up-to-date. It also summarizes the testbed settings and the stated accuracy of various solutions. The WiFi device-free solutions are surveyed by Makki et al., and the WiFi time-based solutions are surveyed by Konings et al. This latest (2019) review by Konings et al. includes experimental results from the authors' own work. He and Chan's 2016 study and Khalajmehrabadi et al.'s 2017 study are the two most recent comprehensive reviews of WiFi fingerprinting. Therefore, it is proposed that further research be conducted on WiFi-based IPS. The new survey is meant to fill in the gaps left by the previously used surveys by providing a comprehensive overview of WiFi-based solutions. However, given the level of interest in this area, it should focus primarily on WiFi fingerprinting.

Since BLE is so compatible with WiFi in the 2.4 GHz band, it has been utilized for locating using the Radio Source Separation (RSS), Angle of Arrival (AoA), and Time of Flight (ToF) methods, with RSS being the most common. As far as the author of this work is aware, BLE has only been implemented for use with device-based IPS. The average BLE detection range is less than 25 meters. As a result of having such a limited detection range, it is less useful for device-free solutions. Since BLE networks often have a higher density of deployed emitters, their achieved accuracies tend to be higher than those of WiFi networks. Although BLE beacons are relatively inexpensive, deploying them in large numbers could be difficult due to scaling issues. In light of the dearth of BLE IPS surveys, we present a quick overview of what we saw as the most important issues for BLE-based positioning. Bluetooth has been used for indoor locating since the early 2000s, initially with the use of proximity and laterally. However, due to its slow scanning speeds, Bluetooth was not suited for accurate localization with minimal delay. With the advent of BLE (2012), Apple's iBeacon protocol, and an abundance of low-cost BLE beacons, Bluetooth's (BLE) use as a positioning method skyrocketed. Positioning with BLE is a relatively new field, however Faragher and Harle have produced one of the most influential early publications on the topic. In that study, we saw how BLE stacks up against

WiFi. It also demonstrated the impact of channel gain disparity on BLE measurements. As so, it demonstrated one of the major difficulties with BLE positioning: a faster fading effect that is more substantial than that observed for WiFi. In addition, Faragher and Harle provided instructions on how to use a moving window to average measurements and enhance signals' measurement mistakes, paying special attention to factors like potential walking movement, fast fades, and the rate at which clients get adverts. In order to handle BLE quick fades, Palumbo et al. devised an approach based on a map that mimics a trail diffusion. An increase in advertisement frequency and a greater density of beacon deployments were shown by Kriz et al. to improve location accuracy. When deciding where to place BLE emitters, only the positioning need be taken into account, unlike with WiFi. On the other hand, this presents the difficulty of determining the optimal number of beacons and broadcasting parameters for a certain location. Sometimes it is believed that beacons will be placed uniformly across a certain area, while other times the environment imposes stringent limitations on where they can be placed. After checking out a number of factors including moving windows size, windows aggregation method, beacon advertising frequency, and transmission power, Faragher and Harle concluded that a comprehensive search of the parameter space was impossible. To improve indoor localization, Budina et al. proposed an optimal distribution of iBeacons, in which a set number of beacons would be strategically placed about the room. Their method takes into account the structure's layout and separates the target region into cells for individual evaluation. As they put it, optimization coincides with picking up on enough devices with a strong enough signal to do so. The specifications of the beacon installation were investigated by Castillo-Cara et al., who focused on transmission power, density, and topology. In order to improve categorization, they suggested dividing the target area into broad sections while retaining intervals between them. They also recommended avoiding positions near windows and using low or medium transmission powers, with consideration given to the materials used in the construction of the walls. They also suggested installing beacons at the area's intersections and at its center, as well as at regular intervals of 7 meters. They conducted simulations of a grid deployment. Some recent suggestions include Rezazadeh et al.'s study of an environment, in which they examine the vertical and horizontal placements of beacons to boost the observed intensity of each beacon and, by extension, the likelihood of seeing at least three of them from any given position. For WiFi networks, fingerprinting is the standard security measure. However, various solutions for BLE are possible depending on the deployment and environment due to the larger density of emitters and their shorter detection ranges. When estimating where beacons were located, Aman et al. used their geometric center as a pivot point.

Higher mean RSS, received advertising count ratios, and variance were all found to be associated to closer proximity to a beacon in a study by Bouchard et al. So, the authors picked the beacon's location based on the highest value of the combined weights of the three measures. Whether or not specified weights were assigned to each detected emitter was a test case for the centroid that Muoz-Organero et al. In more recent work, Mendoza-Silva et al. compared the centroid of the placements of the detected beacons across two distinct environments, with the importance of each location being weighted according to the beacon's relative signal strength (RSS). Compared to fingerprinting, the weighted centroid's accuracy was much better. used a method called stigmergy, which, through repeated updates, generates a map simulating the dissemination of a trail based on a series of position estimates. Very few BLE-based IPS works have made use of lateration. used it with specific gear while only thinking about LOS scenarios in which the sender and receiver were at the same altitude.

#### **IV. Discussions**

One of the characteristics of the current status of IPS, according to researchers working in the field of indoor positioning, is the lack of a clear, widely used technology or approach for IPS. It is challenging to establish a general solution that works in most scenarios because of the variety of surroundings and applications. Some surveys provide evaluation criteria that allow readers to compare the surveyed works as well as learn more about the qualities of the writers' top picks for the most noteworthy works. The enormous number of solutions that have been put out over the years, but only a few number have had significant academic impact, is another characteristic of the current state of IPS. On DOIs, the relationship is based. The plan is to build an undirected network utilizing each survey's DOI as the link information, linking the surveys to the papers they cite. We understand that not every scholarly work is covered by this strategy. Old papers, papers presented at obscure conferences, technical reports, patents, books, and online sources are only a few examples of materials without DOIs. There were publications that were cited up to 15 times in the chosen surveys during the curation but had no DOI. In the surveys, the majority of the papers without a DOI were mentioned twice or three times. The DOI approach was chosen since it is quite straightforward and enables machine analysis. The majority of current scholarly articles that are published in reputable resources also have a DOI.

The curation was done manually and automatically. Web scraping for reference extraction and DOI discovery utilizing Crossref's Link References matching tool were two examples of automatic methods. After using automatic tools, a manual revision was done to fix any discrepancies that the web scraping and DOI discovery processes had left behind. The 62

selected surveys were processed to create 3950 original works, including surveys that weren't part of the initial 62. These divergent studies include specific focuses like SLAM, visual odometry, RFID, multidimensional scaling methods, and those that have been published in conference proceedings. It is crucial to note that certain conferences have severe page limits, which frequently force authors to condense their list of references to just the most pertinent ones. The studies that are frequently cited by other works are those that are near to the middle of the graph. Inertial sensor solutions, WLAN-based solutions, solutions tailored for pedestrians or smartphones, generic surveys, and solutions that prevent or minimize the site survey efforts are the primary topics covered in those surveys. The degree of the node that represents a work in a graph, or the quantity of its incident edges, determines how many times that work has been cited. There are 67 works that have been highlighted. Even without accounting for the chosen surveys, it is a rather small amount in comparison to the overall number of books cited. In fact, without taking into account the chosen surveys, the average number of citations for a publication is 1.49. This low percentage is noteworthy not only because it suggests that most articles are mentioned just once, but also because the works that were taken into consideration included surveys, which were published prior to 2017 and were not included in the surveys chosen for this study. The majority of the cited works are cited just once in the chosen surveys, although several are cited twice. There are extremely few works that are mentioned more than five times. The dispersion of citation counts may indicate that

- (1) The surveys frequently have very narrow scopes and little overlap in content,
- (2) The suggested remedies quickly become outdated,
- (3) It is challenging for IPS surveys to determine the applicability of the suggested fixes.

They were given a category in order to categorize and examine the technology-related focus of the chosen surveys. Several of the surveys that were categorized in the category "Several" do not address light-based IPS, either because they are limited to network-based technologies or because they are technologies that are fully supported by smartphones, despite the fact that the data from the table may suggest that light-based IPS are as popular as WiFi-based IPS. Additionally, surveys in the "Several" category cover subjects that are extremely pertinent to WiFi-based IPS but are not specifically related to WiFi, such as crowdsourcing, fingerprinting, building radiomaps, and IPS for smartphones. This analysis took the 55 non-survey publications that were most frequently cited in the chosen surveys to further investigate the emphasis of the present IPS research. Because our attention was on IPS ideas, we didn't include surveys among the 59 works. Furthermore, surveys frequently contain citations since



they are cited in later, related surveys and utilized as references in broad descriptions of a subject. The most common technology used in IPS proposals is WiFi. WiFi appears to be followed by wireless and lighting technologies, both of which contain WiFi. Nearly half of the 59 non-survey publications that received the most citations were written between 2011 and 2013. Given that they were largely pioneers in the indoor positioning field and have continued to maintain their research significance, the trend in their publication years was expected. It is challenging to predict how long they will be valuable. Up until a new technology—at least less expensive than UWB—becomes broadly accessible for usage with smartphones, WiFi, BLE, and light appear to be the front-runners. The reviews that were picked to discuss light are from the years 2016 to 2019, which emphasizes the rising importance that this technology is receiving. Regarding WiFi, research on WiFi-based IPS will continue because it is a solution that requires no infrastructure other than the widespread AP that is already in place and as long as smartphones can continue to do WiFi scanning at reasonable rates to offer close to real-time positioning. The maximum number of WiFi scans allowed by the current Android version (9.0) was 4 scans every two minutes. For iOS phones, WiFi scanning was already limited. Due to this, certain IPS systems may start to place less of an emphasis on WiFi as a result of the restriction for Android devices. For WiFi-based pedestrian navigation systems that rely exclusively or primarily on WiFi, the new scan rate is too low. Some applications, such in-home monitoring and presence detection for data processing, only need rough, non-real-time position estimates, thus the new scan restrictions shouldn't have much of an impact on them. BLE, which offers more accurate estimations than WiFi, will also continue to be an option for IPS. It is in fact well-liked by IPS supply businesses. The 55 non-survey papers that received the most citations were included in the final batch of analysis from this section. The correlation analysis shows a statistically significant somewhat positive association between the two citation measures. But some books that received few citations in the surveys might receive several citations in Google Scholar. The work of Arulampalam et al., which offered a tutorial on particle filters, is one example. Only 11 people have cited that work in surveys, although Google Scholar lists almost 12,000 references to it. It is applicable to IPS but does not concentrate on IPS and is pertinent for a wide range of positioning and navigation-related topics. Despite having 30 citations in the chosen surveys, the study that introduced the RADAR IPS had fewer citations in Google Scholar than the work of Arulampalam et al.

## **V. Conclusions**

Based on earlier studies, this report provided an examination of indoor positioning systems. The present status of indoor positioning is examined in this study based on the works

cited and referenced in previously published surveys, as opposed to typical surveys, which analyze various indoor positioning technologies and cutting-edge works. The key technologies that are currently used to support indoor positioning systems were discussed in the study, along with a brief description of the processes and approaches used in each. The reader can use this article as a collection of connections to more specialized surveys because each technology's description is backed up by references to other surveys. The most common method for indoor locating, based on WiFi and BLE fingerprinting, is discussed in-depth, along with the most well-known issues in this area. The meta-review demonstrates that the majority of cited publications in reviews are not disruptive. A total of 3966 works were mentioned in 69 reviews, but the majority of them were only mentioned once in the chosen surveys. However, only 57 works—which were regarded as well-known or revolutionary—were cited more than 8 times in the surveys that were chosen. In some instances, the polls mention current articles that don't appeal to the specialists in indoor positioning. A few publications that were released in the early 2000s were disruptive and exerted a significant influence on subsequent developments, the meta-review also reveals. More than 12,000 citations are found for Radar. In the years between 2015 and 2020, there aren't many works with a moderate influence. The majority of the pertinent research in the surveys is from the years 2020 to 2022, which coincides with the introduction of smartphones as we know them now and the growth of new conferences on the subject, such the International Conference on Indoor Positioning & Indoor Navigation.

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