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An Evaluation of the Central Sewage System (CSS) Problem in Abuja

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ABSTRACT

The Abuja Central Sewage System (CSS) is an essential facility in the capital city. The CSS efficiency must not be compromised due to the enormous effects of sewage malfunction on the environment and its inhabitants. This research aims to study the problem of the Abuja Central Sewage System (CSS) problem, identify related issues, and provide alternative solutions. To achieve this goal, field research was undertaken in Phase 1 of the Federal Capital City (Abuja), with a questionnaire randomly administered to two hundred respondents in five (5) districts. The survey questionnaire was given to only building tenants acquainted with building services, particularly liquid waste disposal, such as the underground sewage system. The data were evaluated with descriptive statistical methods like percentages, means, and standard deviation. It was established that sanitary sewers overflowed from manholes onto streets and eventually into storm drains. The waste is not treated before being deposited into surrounding watercourses. It was also revealed that manholes release foul odors from sanitary sewers. These hazards pollute the environment and endanger public health. The study concluded that the Federal Capital City's sanitary sewers were somewhat successful in collecting and transporting sewage. The study suggested improving service delivery efficiency through routine training in collection system operations, maintenance, and supervision, as well as integrating cutting-edge technologies like closed-circuit television into the sewer system's maintenance program to increase the sewer efficiency system.

Keywords: *Sewage; Manholes; Treatment Plant; Waste; Central Sewage System*

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INTRODUCTION

The Abuja Central Sewage System is a vital facility in the capital city. Its operational efficiency must not be jeopardized due to the enormous health, sanitation, and socioeconomic consequences. Sewage breakdown, malfunction, or incomplete processing can devastate the environment and its inhabitants (Nwaokwa, Mustapha, & Sani, 2013). Waste and other pollutants require efficient waste collection, transportation, treatment, recycling, and disposal (Saminu, Chukwujama, & Dadan Garba, 2017)). Environmental hazards are mostly and popularly traced to pollution problems arising from these wastes' inadequate and inefficient management (Speight, 2020; Wang et al., 2013). Disposing of this raw sewage and un-disinfected (incompletely treated or processed) liquid waste into rivers, streams, and farmlands pollute the environment and causes health and sanitation problems for the inhabitants. It also degrades the rivers and streams, possibly water supply sources needed for domestic uses. A close observation of the Federal Capital City (F.C.C.) Central Sewage System (CSS) reveals a lot of missing links and manholes.

Because of Abuja's favorable terrain, the sewage system is a gravity-collecting system with no powered devices. To lessen the strain on the wastewater treatment facility, a separate system is implemented in which storm runoff is excluded from entering the stationary sewage system. The building of the interceptor sewage schedules I and III, which transport sewage from the city to the wastewater treatment facility, has reached 90 and 97 percent completion, respectively, while only 65 percent of Schedule II has been completed (Saminu et al., 2017). The construction of the pilot sewage treatment plant to serve the city's original population of around 200,000 inhabitants was awarded in 1981 and is only about 65% completed. Temporarily, most of the city's populated areas were equipped with septic tanks deemed appropriate for the current population. Despite the vast sums of money previously invested by the federal government for proper sewage disposal, the management of the sewage system is fraught with issues as development is still ongoing, particularly on the treatment plant. Active sewer lines are routed into streams, posing a threat to city residents

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and the environment. Additionally, there is the issue of clogged pipes creating flooding in the majority of the city(Saminu et al., 2017).

In Phase I of the Federal Capital City (F.C.C) Abuja, most buildings are connected to the CSS. However, less than half of the liquid waste from these areas reaches the treatment plant for processing (Garba, 2012). About half of this waste ends up in aerators (mini-treatment plants without ultraviolet ray stations) and lagoons located at designated points in the districts (Nwaokwa et al., 2013). A good percentage also spills uncontrollably into farmlands (Saminu et al., 2017). The sight of sewers overflowing in several districts of the Federal Capital City (F.C.C.) is all too familiar. These are called sanitary sewer overflows (SSOs). These SSOs flow into the street and eventually end up in the storm drains, separate systems whose discharges are not treated before release into surface watercourses. Sometimes, a sanitary sewer overflow is observed as stagnated water when it's impossible to flow into storm drains. Such an occurrence is a common source of water quality problems, posing a risk to human and environmental health(Saminu et al., 2017).

In addition, the sewer systems emit foul odors through nearby maintenance hole covers due to hydrogen sulfide off-gassing and stagnated sewage flow. The potential health and environmental risks resulting from these overflows and odorous emissions justify the need for the sewage collection and conveyance system to be optimized for maintenance and operation. This is because these emissions affect the comfort and safety of the city's inhabitants. This paper's central focus is to assess the Abuja Central Sewage System (CSS) problem to identify its associated problems and recommend possible solutions to the identified problems.

THE STUDY AREA: FEDERAL CAPITAL CITY (F.C.C.)

Abuja is a segment of the Federal Capital Territory (F.C.T.), which include Federal Capital City (F.C.C.) and other nearby settlements. (Enoguanbhor, Gollnow, Nielsen, Lakes, & Walker, 2019). It is flanked by numerous satellite towns such as Kubwa, Karu, Kwali, Kuje, Gwagwalada, and Abaji. Abuja is in the center of Nigeria (Figure 1), north of the

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convergence of river Niger and Benue (Abubakar, 2014), and occupies approximately 8,000 m2 (Mahmoud, Duker, Conrad, Thiel, & Ahmad, 2016). It lies between latitude 9° 03' and 9° 07'N and longitude 7° 26' and 7° 39'E in the North-central part of Nigeria (Agbelade, Onyekwelu, & Oyun, 2017). Kaduna State bounds it to the north, Niger State to the west, Nasarawa State to the east and northeast, and Kogi State to the south.

Abuja is a planned city conceived in 1976 but was officially relocated to in 1991, replacing Lagos as Nigeria's new capital city. The planned development of the city began in 1980 following extensive surveys. The Capital City is divided into four (4) phases of development (Figure 2), with Phase I now almost completed. The Phase I area occupies approximately 250 square kilometers and is divided into the Central Area and two roughly parallel development corridors radiating outward from the Central Area. The corridors are divided into discrete sectors that are connected by transit ways. The sectors are planned to be substantially self-contained service systems and contain concentrations of formal commercial and government employment sectors, along with the highest levels of public services. Each sector is organized around a sector center traversed by the transitway and further subdivided into population districts of about 40,000 inhabitants. In total, there are four (4) residential districts in the Phase I development area: Maitama, Asokoro, Wuse I & II, and Garki I & II (Abubakar, 2014; Laryea, Leiringer, & Hughes, 2010). About 250,000 inhabitants are expected to be accommodated in these four (4) districts of Phase I of the City (Abubakar, 2016). The fifth district, Central Area, is a governmental and business area. It is made up of three zones, as follows:

i. Zone I: The National Assembly, the Supreme Court, and the Presidential Complex are all located here.
ii. Zone II: This comprises Eagle Square and malls. It also contains government offices, ministries, and foreign embassies.
iii. The Central Business District is where private and commercial activities are concentrated.

The Master Plan for Abuja's development envisioned creating a new capital city based on modern engineering concepts similar to those used in most of the world's capital cities. When

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the city is fully completed, it will have enough engineering infrastructure, including power, water, and sewage systems, to support a planned population of 3.1 million people. (Anonymous, 1994).

The temperature in F.C.T. is warm all year, with maximum temperatures ranging from 28 to 35 degrees Celsius between February and April and the lowest temperatures ranging from 16 to 25 degrees Celsius between November and January(Gbadegesin & Ayileka, 2000). The temperature varies throughout the day, from 40 °C in the afternoon to 16 °C at night. The yearly rainfall ranges from 1000 to 1600 mm, with 1400 mm being the average. The wettest month is August, with roughly 317 mm of rain, and the wettest month is December, with only 1mm of rain. During the rainy season, relative humidity in the region reaches over 50%. In contrast, during the dry season, it reduces to between 20% and 40% (Mustapha, Hassan, Hafeez, AbdulNasir, & Onubi, 2022).

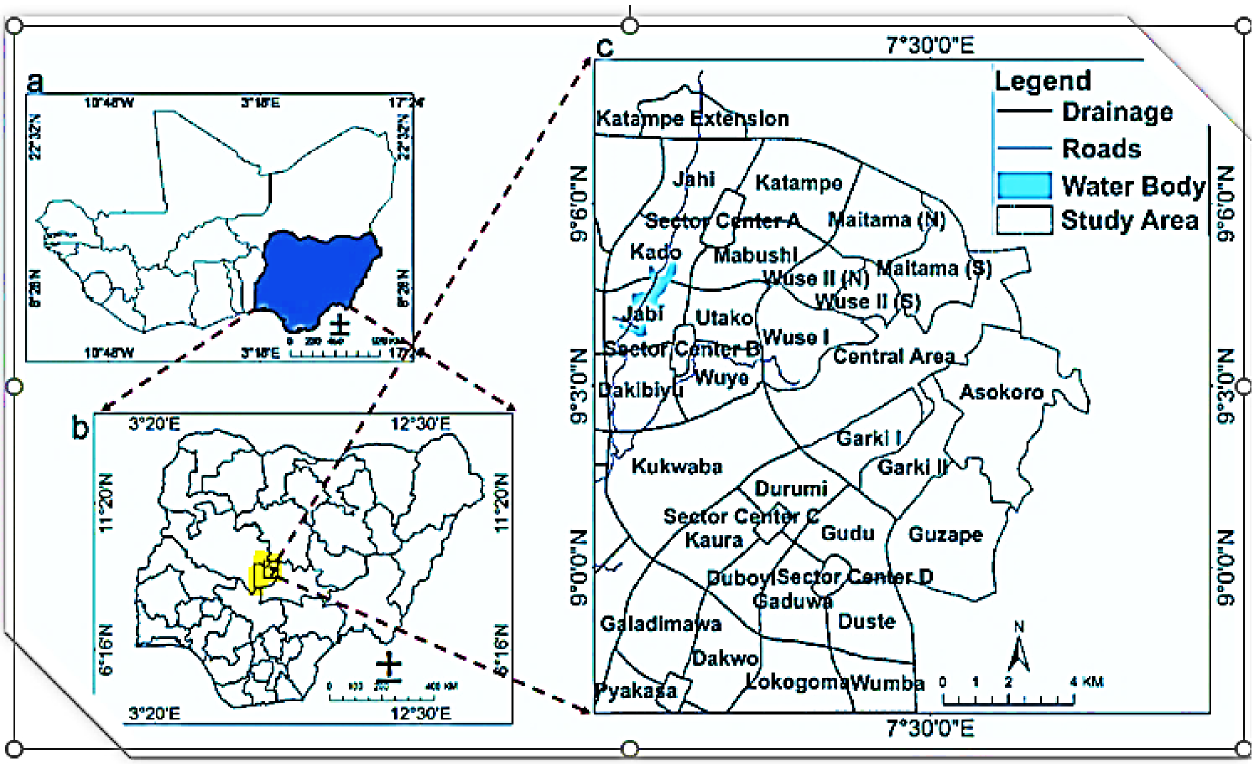

Figure 1: Location of research Area (a) West Africa inset Nigeria (b) Nigeria insert F.C.T., Abuja city in yellow and (c) Abuja city showing key neighborhoods

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Source: Adapted from (Mahmoud et al., 2016)

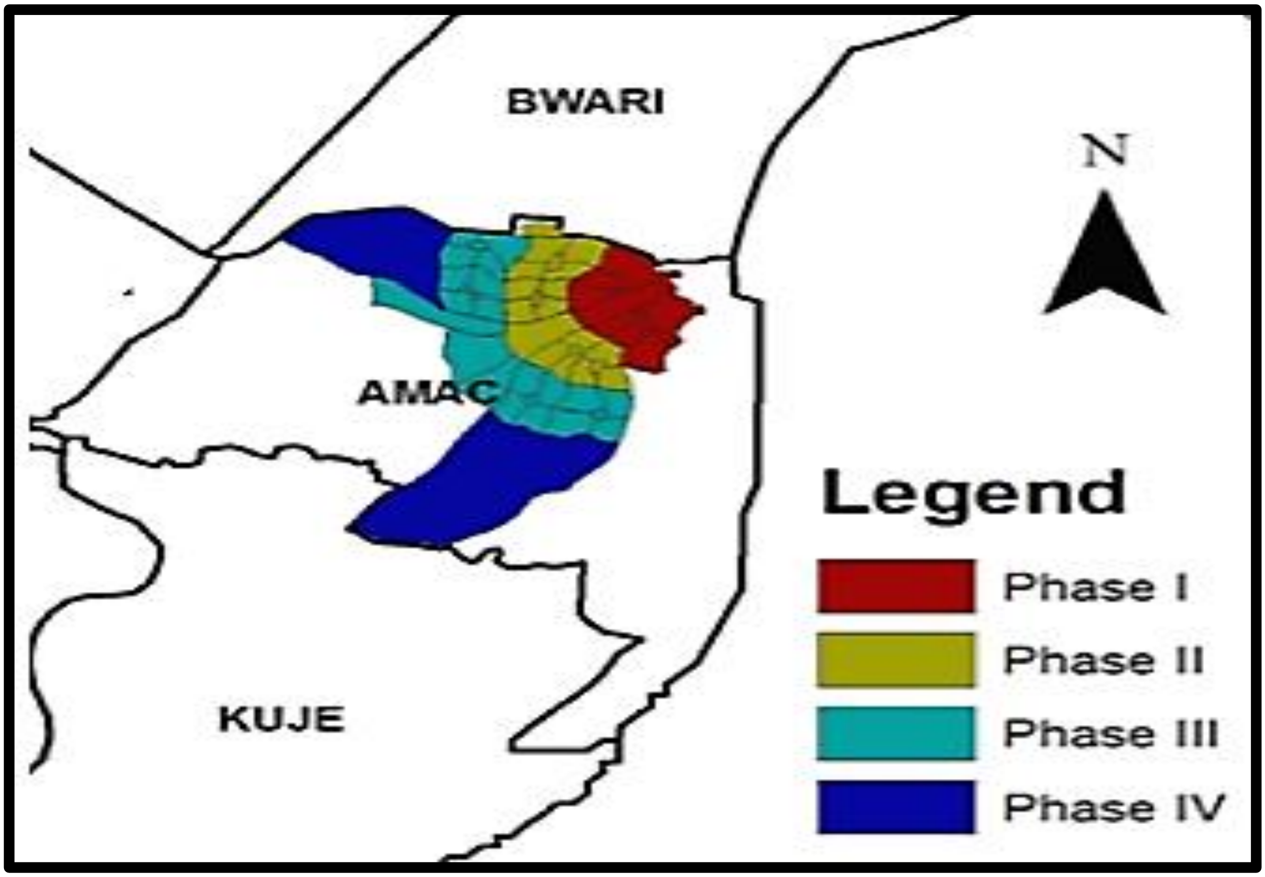

Figure 2: Map of Abuja City showing Phase I-IV.

source: http://www.abujagis.org.ng

THE FEDERAL CAPITAL CITY CENTRAL SEWAGE SYSTEM AN OVERVIEW

The F.C.C. Central Sewage System is gravity-fed, with no lift stations, force mains, or other powered devices (Laryea et al., 2010). This type offers several advantages over pumped systems, including cheaper operating and maintenance costs, a decreased chance of catastrophic system failure, easier construction phasing (including expansion), and no energy requirements. The system was developed to match the city's growth by segregating industrial and domestic sanitary sewage system wastewater outputs with the option for eventual re-use of the treated wastewater. Storm runoff is not permitted to enter the sanitary sewerage

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system because it is a separate waste collection system. The following are the primary components of the central sewage system:

i. The Interceptor Sewer Systems, and
ii. The Main Sewage Treatment Plant

i. The Interceptor Sewers

The interceptor sewer system consists of a network of conduits and reinforced precast and ductile iron pipes that transfer raw sewage from neighborhoods to the sewage treatment facility. The designations provided to interceptor sewer systems for simplicity of design and installation are Schedules I, II, and III. The interceptor sewer system transports raw sewage from communities to the sewage treatment facility via conduits and reinforced, precast, and ductile iron pipes. Schedules I, II, and III are the designations given to interceptor sewer systems for ease of design and installation.

a. Interceptor Sewer Schedule "I"

The interceptor sewer schedule I collect sewage from schedule III, Garki I, and II Districts.

b. Interceptor Sewer Schedule "II"

The Interceptor Sewer Schedule II collects the entire quantity of sewage conveyed by Schedules I & III and conveys the same to the Main Sewage Treatment Plant.

c. Interceptor Sewer Schedule "III"

The Interceptor Sewer Schedule III collects sewage from Asokoro, Maitama, Wuse I & II Districts and part of the Central Area.

ii. The Main Sewage Treatment Plant

The Abuja Main Sewage Treatment Plant is situated in Wupa and is planned to serve 700,000 people (Laryea et al., 2010). It is a cutting-edge facility that is fully automated and programmed to treat an unending wastewater flow by aerobically breaking down microorganisms found in the wastewater before dumping the purified effluent into nearby river basins. The main sewage plant includes the screening plant, grit removal chamber, influent pump station, aeration tanks, final clarifying tanks, sludge treatment, and other support equipment.

Other components include:

i. Manholes - Precast concrete rings or reinforced concrete risers and cones;
ii. Manhole Cover - Precast concrete or steel iron.
iii. Pipes - precast concrete, ductile iron, and P.V.C. pipes

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Figure 3 *Shows Abuja Wastewater Treatment Plant*

METHODOLOGY

The field survey was carried out in five (5) districts of Abuja's Phase 1: Garki I & II, Wuse I & II, Maitama, Asokoro, and Central Area. A total of 300 buildings were surveyed (sixty buildings from each district), out of which a sample of two hundred (200) buildings were selected. In order to accomplish the desired objectives, questionnaires were prepared and sent randomly to tenants of the sample buildings. Personal interviews with the respondents were also done to ensure they understood the research problem.

The survey questionnaire was given to only building tenants acquainted with building services, particularly liquid waste disposal, such as the underground sewage system. Efforts were made to guarantee that the questionnaire was completed correctly by offering required clarifications to respondents on specific questions. A total of two hundred (200) questionnaires were distributed, and data was collected and analyzed using them. The results were presented in tables after the data from the questionnaires was evaluated using descriptive and simple statistical methods such as percentages, averages, means, and standard deviation. The analysis results were used to

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make inferences about the phenomenon under study.

DATA PRESENTATIONS AND ANALYSES

Data generated from the field survey questionnaire were analyzed and presented in the form of tables with brief descriptions:

i. Questionnaire Administration and Distribution

The field survey administered two hundred (200) questionnaires. Ninety-four percent (94%) of the questionnaires were completed and returned, while six percent (6%) were not returned. The results are presented in Tables 1.1 and 1.2.

Table 1.1: Questionnaire Administration

Questionnaires	Frequency (f)	Percentage (%)
Returned	188	94
Not Returned	12	6
Total	**200**	**100**

Table 1.2: Distribution of Returned Questionnaires

District	Number Administered	Number Returned	%	Number Not Returned	%
Garki I & II	40	40	100	0	0
Wuse I & II	40	40	100	0	0
Maitama	40	36	90	4	10

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Asokoro	40	35	87.5	5	12.5
Central Area	40	38	95	2	5
Total	100	189		11	

Forty (40) questionnaires were administered to five (5) districts. 100% of the questionnaires administered to Garki I & II and Wuse I & II Districts were returned, while 90%, 87.5%, and 95% of the questionnaires administered to Maitama, Asokoro, and Central Area Districts, respectively, were returned.

ii.Building Types Sampled and Use of Premises

The field survey was carried out in five (5) districts of the Federal Capital City, Abuja: Garki I & II, Wuse I & II, Maitama, Asokoro, and Central Area Districts. The building types sampled were: bungalows, detached houses, duplexes, apartment blocks, and office blocks. The uses of premises for these building types sampled were: residential, business/commercial, and institutional. The results are described in Tables 1.3 and 1.4:

Table 1.3: Building Types Sampled

District	Bungalow	Detached House	Duplex	Apartment Block	Office Block
Garki I & II	4	4	8	20	4
Wuse I & II	4	8	10	14	4
Maitama	6	8	16	8	2
Asokoro	4	1	16	8	2
Central Area	2	0	0	10	28
Total	20	30	50	60	40

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Table 1.4: Use of Premises Sampled

District	Residential	Business/ Commercial	Institutional
Garki I & II	26	10	8
Wuse I & II	22	16	2
Maitama	30	8	2
Asokoro	32	4	4
Central Area	10	22	4
Total	120	60	20

iii. Occurrence of Sanitary Sewer Overflows (SSOs)

The occurrence of sanitary sewer overflows from sewers, manholes, and other associated structures was investigated. The results are presented in Table 1.5. It shows that SSO occurrences were highest in the Wuse I & II District, where 100% of respondents indicated the occurrence of sanitary sewer overflows. Responses to these overflows in the other districts are Garki I & II (90%), Maitama (94%), Asokoro (94%), and Central Area (53%).

Table 1.5: Occurrence of Sanitary Sewer Overflows (SSOs)

	Response					
District	SSOs occur		SSOs do not occur			
	Frequency (f)	%	Frequency (f)	%	∑f	%
Garki I & II	36	90	4	10	40	100
Wuse I & II	40	100	0	0	40	100

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Maitama	34	94	2	6	36	100
Asokoro	32	94	2	6	34	100
Central Area	20	53	18	47	38	100

iv. Determination of Locations of Sanitary Sewer Overflows

The responses recorded in determining the locations of the occurrences of sanitary sewer overflows are presented in Table 1.6 below:

Table 1.6: Locations of Sanitary Sewer Overflows

	Response						
District	**Sewer Lines**		**Manholes**		**Other Locations**		
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**∑f**
Garki I & II	2	6	32	89	2	6	36
Wuse I & II	2	5	38	95	0	0	40
Maitama	0	0	32	94	2	6	34
Asokoro	2	6	28	88	2	6	32
Central Area	0	0	20	100	0	0	20

Table 1.6 indicates that SSOs occur in sewer lines for 6% of respondents in Garki I & II and Asokoro, and 5% in Wuse I & II, respectively.

Responses from the five (5) districts show that overflows mostly occur at manholes: Garki I & II (89%), Wuse I & II (95%), Maitama (94%), Asokoro (88%) and Central Area (100%). 6% of respondents in Garki I & II indicated SSO occurrence in other locations.

v. Determination of Frequencies of Sanitary Sewer Overflows

Table 1.7 shows that 39% of the respondents in Garki I & II often experience SSOs, and

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responses recorded from other districts for the frequency of SSOs are Wuse I & II (40%), Maitama (29%), Asokoro (31%), and Central Area (30%).

Table 1.7: Frequencies of Sanitary Sewer Overflows

	Response									
District	Very Often		Often		Not Often		Not at All			
	Freq. (f)	%	Freq. (f)	%	Freq. (f)	%	Freq. (f)	%	∑f	%
Garki I & II	4	11	14	39	18	50	0	0	36	100
Wuse I & II	10	25	16	40	14	35	0	0	40	100
Maitama	2	6	10	29	18	53	4	12	34	100
Asokoro	0	0	10	31	20	63	2	6	32	100
Central Area	0	0	6	30	14	70	0	0	20	100

vi. Reporting of Sanitary Sewer Overflows to the System Operator

From the results presented in Table 1.8 below, it is seen that respondents largely do not report SSO occurrences to the System Operator. Respondents who do not report SSO occurrences are highest in Asokoro District, with 94% of responses. This is followed by Wuse I & II (90%), Garki I & II (83%), Maitama (82%), and Central Area (80%). During the field survey, Some respondents claimed they didn't know where to report SSOs, while others said they assumed the system was under operator surveillance.

Table 1.8: Reporting of Sanitary Sewer Overflows to the System Operator

	Response				
District	SSOs Reported		SSOs Not Reported		
	Freq. (f)	%	Freq. (f)	%	∑f

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Garki I & II	6	17	30	83	36
Wuse I & II	4	10	36	90	40
Maitama	6	18	28	82	34
Asokoro	2	6	30	94	32
Central Area	4	20	16	80	20

Determination of Frequencies of Sanitary Sewer Overflow Stoppages and Clean-ups

Table 1.9 shows the findings for the frequency of SSOs stopping and cleaning up in the five (5) districts. The results show that 47% of respondents in Maitama do not often notice SSOs' stoppage and cleaning up. Similar results for other districts are Central Area (60%), Garki I & II (50%), Asokoro (44%), and Wuse I & II (35%). A fairly high percentage of respondents do not notice this event at all: Garki I & II (33%), Wuse I & II (40%), Maitama (29%), and Asokoro (31%).

Table 1.9: Frequencies of Sanitary Sewer Overflow Stoppages and Clean-ups

	Response								
District	**Very Often**		**Often**		**Not Often**		**Not at All**		
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**∑f**
Garki I & II	2	6	4	11	18	50	12	33	36
Wuse I & II	2	5	8	20	14	35	16	40	40
Maitama	4	12	4	12	16	47	10	29	34
Asokoro	2	6	6	19	14	44	10	31	32
Central Area	2	10	6	30	12	60	0	0	20

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Perception of Sewer Foul Odours

Table 1.10 shows the findings of the investigation into sewage odor perception. It shows that foul odors were perceived in the five districts of the study area. Foul odors were indicated to be perceived 100% in Garki I & II, 95% in Wuse I & II, 94% in Asokoro, 80% in Maitama, and 68% in Central Area.

Table 1.10: Perception of Foul Odor from the Sewers

	Response					
District	**Odor is Perceived**		**Odor is not Perceived**			
	Freq. (f)	**%**	**Freq. (f)**	**%**	**∑f**	**%**
Garki I & II	40	100	0	0	40	100
Maitama	32	80	4	12	36	100
Asokoro	32	94	2	6	34	100
Wuse I & II	38	95	2	5	40	100
Central Area	26	68	12	32	38	100

vii. Determination of Locations of Perception of Foul Odours

Respondents from the five (5) districts reported that foul odors constantly emanate from manholes located within their premises. The results are recorded in Table 1.11 below:

Table 1.11: Locations of Foul Odor Emissions

	Response						
District	**Sewer Lines**		**Manhole**		**Other Locations**		
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**∑f**
Garki I & II	2	5	34	85	4	10	40

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Wuse I & II	4	10	36	90	0	0	40
Maitama	2	6	34	94	0	0	36
Asokoro	2	6	30	88	2	6	34
Central Area	6	15	32	84	0	0	38

viii. Determination of Frequencies of Perception of Foul Odours

It was discovered that a good proportion (40%) of the respondents from Garki I & II and Wuse I & II (35%) perceived the odor from the manholes very often. 50% of respondents in Wuse I & II and Maitama Districts often perceive foul odors from the sewers. Similarly, 47% and 32% of respondents from Asokoro and the Central Area often perceive foul odor from the sewers, respectively. Table 1.12 below depicts the results:

Table 1.12: Frequencies of Foul Odor Perception

District	Response								
	Very Often		Often		Not Often		Not at All		
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	∑f
Garki I & II	16	40	16	40	8	20	0	0	40
Wuse I & II	14	35	20	50	6	15	0	0	40
Maitama	2	6	18	50	16	44	0	0	36
Asokoro	2	6	16	47	16	47	0	0	34
Central Area	2	5	12	32	24	63	0	0	38

ix. Determination of Frequencies of Odour Control Activities

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For this investigation, respondents from Garki I & II (85%) indicated they had not observed these activities. This observation is corroborated by 82% of respondents from Asokoro, Wuse I & II (70%), Maitama (61%), and the Central Area (58%). These responses are indicated in Table 1.13 below.

Table 1.13: Frequencies of Odor Control Activities

District	Very Often		Often		Not Often		Not at All		
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**∑f**
Garki I & II	0	0	0	0	6	15	34	85	40
Wuse I & II	0	0	2	5	10	25	28	70	40
Maitama	0	0	0	0	14	39	22	61	36
Asokoro	0	0	0	0	6	18	28	82	34
Central Area	0	0	2	5	12	32	22	58	36

x. Determination of Seasons of Perception of Foul Odours

It was observed by the respondents that foul odor emissions occur more frequently in the dry season. The result obtained shows the following observations: Garki I & II (50%), Wuse I & II (55%), Maitama (44%), Asokoro (53%), and Central Area (37%). Table 1.14 depicts the results:

Table 1.14: Seasons of Foul Odor Perception

District	Rainy Season		Dry Season		Not Seasonal		
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**∑f**

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Garki I & II	10	25	20	50	10	25	40
Wuse I & II	10	25	22	55	8	20	40
Maitama	12	33	16	44	8	22	38
Asokoro	10	29	18	53	6	18	34
Central Area	14	37	14	37	10	26	38

xi. Assessment of the Condition of the Sewers

Responses for this assessment indicated that the sewer lines are in good physical condition (80% average), 17% of respondents indicated that the sewers are in fair condition, and 3% of respondents indicated that the sewers are in bad condition. The results obtained are presented in Tables 1.15 and 1.16.

Table 1.15: Condition of the Sewer Lines

	Respondent's Ratings/Frequency (f)							
District	**Good**		**Fair**		**Bad**			
	Freq. (f)	**%**	**Freq. (f)**	**%**	**Freq. (f)**	**%**	**∑f**	**%**
Garki I & II	30	75	8	20	2	5	40	100
Wuse I & II	32	80	8	20	0	0	40	100
Maitama	30	83	6	17	0	0	36	100
Asokoro	30	88	2	6	2	6	34	100
Central Area	28	74	8	21	2	5	38	100
Average	30	80	6	17				

Table 1.16: Condition of the Manholes

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District	Good		Fair		Bad			
	Freq. (f)	**%**	**Freq. (f)**	**%**	**Freq. (f)**	**%**	**∑f**	**%**
Garki I & II	26	65	10	25	4	10	40	100
Wuse I & II	28	70	10	25	2	5	40	100
Maitama	32	89	8	22	0	0	36	100
Asokoro	28	82	4	12	2	6	34	100
Central Area	30	79	6	16	2	5	38	100
Average	28	77	8	20	2	5		

Respondent's Ratings/Frequency (f)

xii. Assessment of the Effectiveness of the Sewer System Maintenance

Table 1.17 shows respondent ratings of the effectiveness of sewer system maintenance on a scale of 0 to 4, where:

0 = Very Poor or Maintenance is never carried out

1 = Poor or Maintenance is only slightly carried out

2 = Fair or Maintenance is fairly conducted

3 = Good or Maintenance is adequately carried out

4 = Very Good or Maintenance is prompt and adequate

Table 1.17: Effectiveness of Sewer System Maintenance

S/No.	Maintenance Activity	Effectiveness Ratings/Frequency					Mean	Stand. Dev.
		0	**1**	**2**	**3**	**4**	**X**	
i.	Routine Inspection of Sewers	18	36	66	48	20	2.09	1.11
ii.	Routine Cleaning of Sewers	24	30	56	52	26	2.13	1.21

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iii.	Repair of Sewers	20	32	60	62	14	2.09	1.10
iv.	Stoppage and Cleaning up of SSOs	26	14	72	64	12	2.12	1.10
v.	Control of Foul Odour	76	72	28	8	4	0.89	0.95

Table 1.17 shows that routine inspection of sewers, routine cleaning of sewers, repairs of sewers, and stoppage and cleaning-up of sanitary sewer overflows have mean ratings above 2 each on a scale of 0–4. This implies that these maintenance activities are fairly carried out. Controlling foul odors has a mean rating of 0.89, which suggests that the activity is never done.

xiii. Impact Assessment of SSO Occurrences and Foul Odour Emissions

Table 1.18 depicts respondent ratings of impact assessment of SSO occurrences and foul odor emission on a scale of 0 to 4, where:

0 = Very Low
1 = Low or Slightly Noticeable
2 = Moderate or Tolerable
3 = High or Irritable
4 = Very High or Very Irritable

Table 1.18: Impact Assessment of SSO Occurrences and The Effects of Foul-Odor Emissions on the Environment and Human Health

S/No.	Impact Parameter	Impact Ratings/Frequency						Mean	Stand.
		0	1	2	3	4	N*	X	Dev.
i.	Surface Water Pollution	44	52	60	22	4	6	1.40	1.05
ii.	Ground Water Pollution	78	62	30	4	2	12	0.81	0.88
iii.	Contamination of Drinking Water Sources	84	68	8	2	0	26	0.56	0.65
iv.	Environmental Degradation	82	50	20	4	2	30	0.70	0.88
v.	Air Pollution	42	30	84	16	12	4	0.53	0.66

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vi. Outbreak of Diseases	92	62	10	2	0	22	0.41	0.52

N* = No Response

The result in Table 1.18 shows that surface water pollution has a mean rating of 1.4, which implies that its impact is low or slightly noticeable. Ground Water Pollution, Drinking Water Source Contamination, Environmental Degradation, Air Pollution, and Disease Outbreaks all have "Very Low" impact ratings (meaning between 0 and 1 on a scale of 0–4).

xiv. Evaluation of the Sewer System's Capacity for Sewage Collection and Transport

Table 1.19 depicts respondent ratings for the assessment of the effectiveness of the Sewer System for Sewage Collection and Conveyance on a scale of 0 to 4, where:

0 = Very Poor or System is not effective
1 = Poor or System is only slightly effective
2 = Fair or System is moderately effectively
3 = Good or System is effective
4 = Very Good or System is adequately effective

Table 1.19: Evaluation of the Sewer System for Sewage Collection and Conveyance Effectiveness

S/No.	**Effectiveness Parameter**	**Effectiveness Ratings/Freq**						**Mean**	**Standard**
		0	**1**	**2**	**3**	**4**	**N***	**X**	**Dev.**
i.	Sewage Collection & Conveyance	4	14	38	92	42	0	2.66	1.23
ii.	System Operation & Maintenance	6	12	64	68	36	2	2.62	0.97
iii.	SSO occurrences	32	42	54	40	20	0	1.86	1.23
iv.	Pollution-Free Environment	10	36	50	52	38	2	2.38	1.16
v.	Foul Odor Problems	36	48	50	32	18	4	1.72	1.24

N* = No Response

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Table 1.19 shows that sewage collection and conveyance, system operation and maintenance, and pollution-free environment have mean ratings above 2, which implies that the system is moderately effective. However, sanitary sewer overflow events and foul odor problems have mean ratings above 1, which implies that the system is only slightly effective due to these problems.

DISCUSSION OF RESULTS

According to the findings, sanitary sewer overflows occur in all five (5) districts in Phase 1 Abuja. The overflow usually occurs in manholes. Findings revealed that routine system maintenance is missing, such as frequent cleaning to eliminate debris that could cause clogs, wastewater inspections, and system monitoring. This is consistent with the findings of Laryea et al. (2010). The findings also reveal that the routine maintenance program is woefully insufficient.

The emission of foul odors was established as another problem associated with using the sewer system. Respondents observed that foul odors are usually perceived from the maintenance holes in the study area. Most respondents indicated that the odor problem is mostly not reported to the system operator and that odor control activities are not often observed to be carried out on the system. When wastewater experiences turbulence or aeration, hydrogen sulphide is generated (a primary source of odors and corrosion in sewage systems). The system operator does not have a program to monitor and control this issue. From the investigation to determine whether these problems are season-dependent, the results showed that sanitary sewer overflows occur more during the rainy season, and foul odors are emitted more during the dry season. From the results, it may be inferred that infiltration and inflow occur in the system during wet seasons, and sewage flow in the sewers may be impeded during dry seasons.

The system operator does not address sanitary sewer overflow occurrences as required. This observation is supported by most respondents, who indicated that the frequency of stoppages and clean-ups they observed is low. In addition, most respondents indicated that they do not report SSO occurrences to the system operator, which may have also contributed to a lack of promptness in abating the problems. It is, however, apparent that public awareness and

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enlightenment about the system's workings are not available.

Analyses of the results obtained for the effectiveness of sewer system maintenance show that routine maintenance activities are pretty carried out. Maintenance activities are required to keep the system and components functioning as initially designed and constructed. The level of effectiveness obtained in the study shows that the current maintenance of the system is inadequate. However, the impact of SSO occurrences and foul odor emissions on the environment and human health was assessed to be slightly noticeable. However, surface water pollution recorded the highest mean rating of 1.4 on a scale of 0 to 4. During the field investigation, it was discovered that raw sewage overflowed from maintenance holes into storm drains, thereby polluting the nearby rivers into which the storm drains discharge. People depend on the water supply from these polluted rivers. This should be a cause for public health concern.

Finally, the F.C.C.'s sewer system was found to be reasonably practical. However, the result needs to be enhanced to ensure that the system is available as intended and that the system's reliability is maintained as planned.

CONCLUSION

The study highlighted some problems arising from using a sanitary sewer system for collecting and conveying sewage in the Federal Capital City (F.C.C.). From the results obtained, it is evident that the maintenance of the system is fair, and the control of foul odors in the system is poor. The sewer system is thus adjudged to be moderately effective based on the parameters used for the assessment.

RECOMMENDATIONS

The following efforts should be taken to remedy the problems with Abuja Central Sewage System:

i. Staff should be trained on collection system operations, maintenance, and regular monitoring by the system operator.

ii. Inspection of the system should be given more attention by designing and implementing a routine schedule inspection, which is essential for appropriate sewer collection system maintenance. Inspections are necessary to create a maintenance program

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since faults cannot be rectified if they are not detected.

iii. Developing and implementing a plan to cope with sanitary sewer overflows is necessary. Sewer overflows into surface waters should be contained and avoided. Health officials and other appropriate agencies should be notified of sewer overflows as quickly as possible.

iv. Hydrogen sulfide monitoring and control should fix the system's odor problems. For the system's maintenance program (CCTV), a computerized maintenance management system (CMMS) and closed-circuit television (CCTV) could be used.

v. A service delivery model that facilitates private sector participation in sanitary sewer operation and maintenance should be used by system owners and/or operators. Such approaches include subcontracting system cleaning and out-tasking system inspection to specialized companies equipped with the requisite instruments and training.

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