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Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 4(1):16-23

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Correlational Analysis of Sewage Disposal Methods and Incidence Rates of Typhoid Fever and Cholera in Port Harcourt Metropolis, Nigeria

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Abstract
This work of correlating incidence rates of typhoid fever and cholera to sewage disposal methods was necessitated by the observed occurrence of typhoid fever and cholera incidences with respect to sewage management approaches. The aim of the work was achieved by observations, interviews and medical records of 25 years (1986 to 2010) from two major health facilities of University of Port Harcourt Teaching Hospital (UPTH) and Braithwaite Memorial Hospital (BMH). The purpose of this work is to highlight the typhoid fever and cholera consequences resulting from improper disposal of sewage. In the first sewage management regime where pit latrines, bucket latrine and pier latrines were used, records show incidence rates of 49% typhoid and 51% cholera for UPTH and 53% typhoid and 47% cholera for BMH. The second sewage management regime where water carriage/closet systems of sewage disposal systems and septic tanks were used, the incidence rate of typhoid fever was 94% and cholera was 6% for both UPTH and BMH. This implies evident correlation of incidences of typhoid fever and cholera with sewage disposal methods in time and space. The increases in the incidences of typhoid fever and cholera are majorly underpinned by poverty, poor food hygiene, poor water sanitation, and generally poor environmental sanitation. Water carriage/closet systems of sewage disposal are here recommended to reduce contamination of food, surface and ground water by sewage.

Keywords: Sewage, typhoid fever, cholera, incidence rate, septic tank, water borehole, buffer distance

INTRODUCTION

The improper use and lack of maintenance sewage systems can result to the contamination of surface water and groundwater, and the subsequent spread of infectious diseases associated with sewage such as: cholera, typhoid fever etc. Anthropogenic activities had unbearably contaminated and polluted surface water resources. However, groundwater is becoming polluted with increasing frequency, and the resulting dangers to man also becoming alarming because polluted water is a very sure pathway of numerous infectious disease causing organisms (L. J. McCabe, et, al; 1970, 670 – 687 and I. Tamunobereton-ari, et al.; 2010)

Port Harcourt is the capital of Rivers State, Nigeria; which is the chief trade centre of Nigeria and the business hub of the country because of its strategic location. Apart from being the main trading centre, Port Harcourt is also a great tourist destination. The economic potentials of Port Harcourt resulted to the influx of investors and visitors that led to the challenges of sewage management (C. V. Izeogu, 1989). Therefore, in the face of increasing demand for potable water supply to domestic and commercial needs, and the consciousness of the pollution potentials of improper sewage management to water bodies and the consequent spread of infectious diseases; the sanitary design, monitoring and maintenance of sewage facilities becomes imperative to prevent and control associated problems.

In this paper, we try to establish the impact of poor sewage management approach on water resources and the consequent spread of typhoid fever and cholera. The importance of this work is to create awareness of the relationship between sewage disposal approach and incidences of typhoid fever and cholera, and to ensure better sewage management regime implemented with resultant healthy populace and reduction of medical bills. We also suggest best sewage management method and control measures to preventing the occurrence and spread of these diseases.

Sewage Disposal Systems

Sewage is the mixture of waste waters and waste matters (faeces and urine) generated from households, commercial premises and factories that

are channelled away through special pipes in a manner not to pose danger and health problems to the environment and man. If sewage is sanitarily handled, it can help to greater extent the prevention of the spread of water and food borne infectious diseases. The common sewage disposal systems include: (a) the direct disposal method (Pit and pier latrines), (b) the conservancy method (bucket and chemical latrines) and (c) the water carriage/closet system. Latrine is a structure or toilet facility built where humans excrete or pass faeces or/and urine (A. H. Hornby, A.H., 1995;, and S. I. Ovu, 2008).

Direct Disposal Method (Pit and Pier latrines)

Pit latrine is a direct sewage disposal method simply to dispose of human faeces and urine into a dug pit. It is simply built with a hole in the ground of about 3m to 6m deep and 1m wide with a small opening created at the surface. The opening is seldomly kept covered when not in use. The solid matter in the faeces is acted upon by bacteria and turned into a liquid, which seeps into the surrounding soil. This system is of two types; one without vent pipe and an improved type with vent pipe that encourages anaerobic decomposition and aerobic decomposition respectively. This method increases air pollution, and enhances the breeding of vectors that transmit the causative agents of diseases and also poses serious danger to the groundwater bodies by the direct seepage of faecal matters and pollutants (S. I. Ovu, 2008).

Pier latrine is also a direct method of sewage disposal system built and used in the coastal areas as shown by Fig. 1, where faeces and urine are disposed of directly into the surrounding water body. This disposal approach directly pollutes the water (especially surface fresh water) thereby facilitate the spread of water borne infectious diseases. Water borne diseases like diarrhoea, typhoid, and cholera have been the cause for an estimated 700,000 deaths in India alone in 1999 (prugent.com, 2012). These diseases mostly hit children under the age of five; and are rampant in India today, and are seriously attributable to these direct sewage disposal approaches and improper water treatment.

Fig. 1a: Pier Latrine constructed with concrete

Fig. 1b: Room design of pier latrine with a central hole

The Conservancy Method (bucket and chemical latrines)

Bucket latrine is a common method of sewage disposal in the urban and suburban areas of developing countries. This method was the major system that was operational in Port Harcourt metropolis since the development of the city from 1913 to the late 1990s. Presently, this system is no longer used due to the awareness created by government and sanitarians on the health and legal implications of the use of such facility. Faeces and urine are passed into a bucket made of galvanized iron or plastic. On daily basis or at the full of the residential sewage bucket, a night soil worker comes and empties the waste into his discharge bucket. The residential sewage bucket container is washed, disinfected and put back in its place, while the sewage is transported to specially designated dumpsite (pit) or landfill for final disposal. The bucket system is insanitary as it creates room for the breeding of vectors (flies) and attracts vermin and increases the risk of faecal contamination of soil, water and food and the subsequent spread of infectious diseases (S. I. Ovu, 2008).

Chemical latrine on the other hand is a water-tight tank containing disinfectants and liquefiers where faeces and urine are passed into. The contents of the tank are discharged continuously into the surrounding soil, or removed at intervals for burial. This type of latrine is useful for isolated premises where the collection and disposal services of an ordinary bucket latrine is not available or possible. This type of latrine is also used in aircraft and trains.

Water Carriage/Closet System

Water carriage/closet system is the most efficient and hygienic method of sewage disposal. In this system, faeces, urine and other waste waters are deposited in a water closet and are flushed with clean water from the cistern. The sewage is conveyed by drains to a septic tank for containment (temporary storage) or to sewers for conveyance to treatment facility or final disposal site. Some of the clean water used for flushing is retained in the water closet, trapped by a U-shaped component; this forms a water seal that prevents the offensive odours from the septic tank or sewer not to reverse back to entering the house; this is shown by Fig. 2. In Port Harcourt sewers are not used to channel away sewage from premises for treatment or disposal rather, every premise has a septic tank for sewage containment purposes, which seems a very convenient way of sewage disposal by premises owners or inhabitants.

Fig. 2a: Water closet showing the U-shaped water seal and Fig. 2b: Cistern that contains clean water for flushing of pipe connecting the water closet to the septic tank the water closet after use.

Septic tank is a large pit constructed in the ground of dimension (2m wide, 3m long, and 4m deep), lined with bricks or concrete. It has an inlet pipe for incoming sewage and an outlet that discharges the liquid contents into the surrounding soil or to a soak-away pit. Sewage in the tank is decomposed anaerobically by bacteria that reduces and transforms most of the suspended solids to liquid. The denser materials sink to the bottom to form sludge, while the lighter solids float at the surface to form scum. Anaerobic and aerobic decomposition continues in the transformation of the sludge and scum to liquid; the liquid content drains out and seeps into the surrounding soil. At the full of the septic tank or periodically, the sludge is evacuated and disposed of at a landfill or into a river or composited and used as fertilizer.

The issue of concern in the water carriage/closet system–is the seepage of the liquid content of the sewage in the septic tank that carries faecal materials and other pollutants towards the groundwater bodies. The high porosity and permeable nature of the subsurface geologic formation materials and the shallow depth of the water table of Port Harcourt make the groundwater bodies highly vulnerable to these pollutants and subsequent exposure of man to associated dangers and diseases (C. C. Plummer, and D. McGeary, 1993)

Allowable standard of buffer distance from septic tank to water borehole is minimum of 15m to maximum above 50m (septic/clearance, 2012). Sewage-related Diseases

Pathogen is a very broad term describing bacteria, viruses, protozoa, and other organisms that may or may not occur naturally in drinking water. Cryptosporidium and E. coli are examples of pathogens that get a lot of attention in the media because there are occasional outbreaks of these pathogens in water supplies across the world. The most common way that these get into drinking water is from faecal matter from sewage discharges, leaking septic tanks, and runoff from livestock feedlots. If such polluted water is ingested, these pathogens can cause cholera, typhoid fever, polio, dysentery, infectious hepatitis, and a host of other health problems ranging from mild intestinal discomfort to death, Figure 3 shows the pathway that cholera can be transmitted from sewage to man (A. A. King, 2008; L. J. McCabe et al. 1970)

Typhoid Fever

Typhoid fever is a systemic infection caused by Salmonella Enterica Serotype Typhi bacteria. This highly adapted, human-specific pathogen has evolved remarkable mechanisms for persistence in its host that help to ensure its survival and transmission. In the 19th century overcrowded and unsanitary urban conditions of the United States and Europe, typhoid fever was an important cause of illness and death, and the provision of clean water and good sewage systems led to a dramatic decrease in the incidence of typhoid fever in these regions (C.M Parry et, al, 2002). Therefore, the influence of water sanitation and sewage management to the incidence rate of typhoid fever cannot be overemphasized.

Typhoid fever is contracted by the ingestion of the bacteria in contaminated food or water. Patients with acute illness can contaminate the surrounding water supply through faeces, which contains high concentration of the bacteria. Contaminated water can taint food supply or flies can carry causative organisms and spread the disease when they perch on contaminated faeces, flow chart of Fig. 3 shows the path way of transmission of the causative organisms from sewage to man. About 3% to 5% of patients become carriers of the bacteria after an acute illness. Some patients suffer very mild illness that goes unrecognized and can become long-term carriers of the bacteria and are sources of new outbreaks of typhoid for many years. The typhoid fever bacteria outside the human host can survive for weeks in water or dried sewage (B.A cunha, 2004),and M.J Paragrigorakis, 2006).

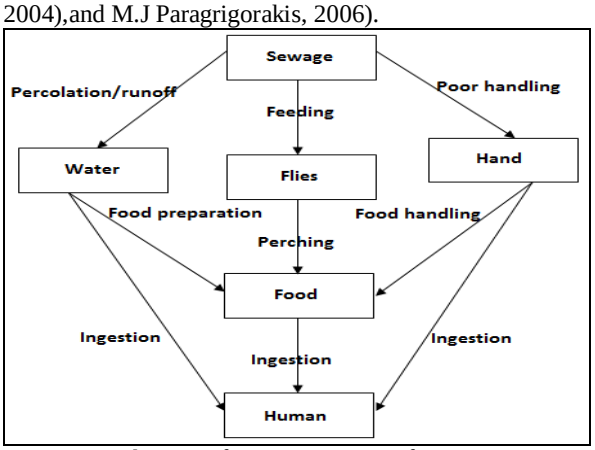

Fig. 3: Pathway of transmission of causative organisms from sewage to man.

After the ingestion of contaminated food or water, the salmonella bacteria invade the small intestine

and enter the blood stream temporarily. The bacteria are carried by white blood cells in the liver, spleen and bone marrow. The bacteria then multiply in the cells of these organs and re-enter the bloodstream. The bacteria also invade the gallbladder, biliary system, and the lymphatic tissue of the bowel and multiply faster. Recent population based studies from South Asia suggest that the incidence is highest in children aged less than 5 years, with higher rates of complications and hospitalisation, and may indicate risk of early exposure to relatively large infecting doses of the organisms in these populations.

Cunha, 2004 and Parry, et al., 2002) and Siddiqui et al., 2006) stated that the symptoms of typhoid fever appear 10 to 14 days after infection and they include: (1). cold and weakness, (2). Generalized aches and pains, (3). Loss of appetite, diarrhoea, and constipation. (4). Temperature rises and remains high ($103^{o}F - 104^{o}F$) for about 10 to 14 days. (5). Body temperature typically rises in the evening and drops in the morning. (6). Skin eruptions and inflamed bones. (7). Tongue becomes dry and gets white patches in the centre, which causes oily taste in mouth. (8). Lethargy (usually only if untreated) affecting practically every body system, and they account for the mortality rate of 7% to 14%. (9). Intestinal bleeding or perforation of the intestine with haemorrhage is not uncommon; especially after two to three weeks of the disease.

Cholera

In many infectious diseases, an unknown fraction of infections produce symptoms mild enough to go unrecorded, a fact that can seriously compromise the interpretation of epidemiological records. This is true for cholera. Cholera is caused by a bacterial infection of the intestine caused by the bacterium vibrio cholerae. In many cases, the infection is mild; sometimes producing no symptoms at all. But approximately one in twenty people infected with cholera has a serious case with symptoms including severe watery diarrhoea, vomiting, and leg cramps. These symptoms quickly cause dehydration, and shock, and can result in death within hours if the infected person does not receive treatment. Cholera is typically transmitted through contaminated food or water. In areas with poor treatment of sewage and drinking water, the faeces of people with cholera can enter the water supply and spread quickly, resulting in an epidemic (King et al., 2008).

The cholera bacterium may also live in the environment in some coastal waters, so shellfish becomes bioaccumulators and when poorly prepared for consumption or eaten raw can be a source of cholera in affected areas. In the 19^{th} century, cholera was common in most industrialized nations, but has been virtually wiped out or eliminated by modern sewage and water treatment systems. Although, some cholera infections can be very severe, and even fatal, the disease can be easily and successfully treated by quickly replacing the fluid and salts lost through diarrhoea. With adequate treatment, less than 1% of cholera patients die from the disease ((King et al., 2008, and jack. 2012).

Data Acquisition

Data for the execution of this work were obtained from both primary and secondary sources. Observation and interview were used to obtain the primary data; while the secondary records were obtained from two health facilities: the Braithwaite Memorial Hospital (BMH) of Rivers State Ministry of Health and the University of Port Harcourt Teaching Hospital (UPTH). The records obtained from both hospitals were properly scrutinized to ascertain the reliability of the acquired data. The data also include case history patients; such as source of drinking water, waste disposal methods, type of residential buildings, income level, literacy level and general environmental sanitation conditions. For the primary source of information, house to house visitation was carried out to actually observe operational sewage disposal methods, the nearness of water sources to septic tanks and general sanitary condition of premises. Interview was conducted to knowing what was obtainable in the past and present with respect to sewage disposal methods, awareness of the impact of improper sewage disposal and the best sewage disposal approach. Interview was also conducted on the issues of water treatment and food hygiene as preventive measures of typhoid fever and cholera.

RESULTS AND DISCUSSION

The respondents from the interview session clearly affirmed that bucket latrine was the sewage disposal method used in the metropolis until late 1990s when it became an eyesore for such facilities, night soil workers banned from working and disposal sites closed. Laws were also enforced by sanitarians to prosecute owners of premises that operate such bucket latrines. While coastal areas in the suburbs of the metropolis still use pier latrines. The respondents also stated that the best sewage disposal method is the water carriage/closet system, which is neater and convenient. On the issues of water treatment and food hygiene, the respondent stated that the treatment and source of water is not of any concern provided the water is clean and odourless, and food hygiene is dependent on the living standard of the people. Rich people care about the environment in which food is prepared, while the poor living in slums and squatters are only interested in getting daily food mindless of how and where is prepared. This was a major

pathway to the spread of water borne and food borne diseases.

The observations made in the course of this work reveals that all premises are now using water carriage/closet systems only connected to septic tanks, no pre-treatment before final disposal. In some areas close to major drainages, sewage discharge pipes are connected to the drains for the disposal of sewages. This approach is insanitary and constitutes environmental hazards. It was also observed that due to lack of supply of potable water by public utilities and relevant agencies, about 70% of premises drilled water boreholes for personal water supply purposes. Almost all the drilled boreholes have no water treatment facilities in their construction. Moreover, buffer distance between the boreholes and septic tanks fall short of the allowable standard of minimum 15m to maximum above 50m (InspectAPedia.com, 2012).

The buffer distances we observed and measured was a maximum of 12 m, and in some cases less than 4m. These shortfalls facilitated the easy contamination of groundwater bodies, and the consequent spread of typhoid fever and cholera.

The extracts from the medical records of the two health facilities used for this work show the monthly records for 1986 and 2010 as presented by Tables 1a and 1b. Table 2 is the annual records from the two health facilities (UPTH and BMH) for the 25 year period. Though, reliable data from which to estimate the accurate burden and incidences of the diseases in Port Harcourt metropolis is difficult, since greater percentage of patients with typhoid and cholera are treated as outpatients. There is indeed more incidence rate than public health records suggest. However, from the available records it is seen from the charts of Figs. 4a and 5a, the incidence rates of typhoid and cholera for both UPTH and BMH at the time (1986) when sewage disposal was by bucket latrine, pit latrine and pier latrine systems. Specifically, the incidence rates of cholera were significant and alarming. This was also supported by the annual percentage distributions of the incidence rates of 49% typhoid and 51% cholera for UPTH and 53% typhoid and 47% cholera for BMH as shown by Figs. 4b and 5b respectively.

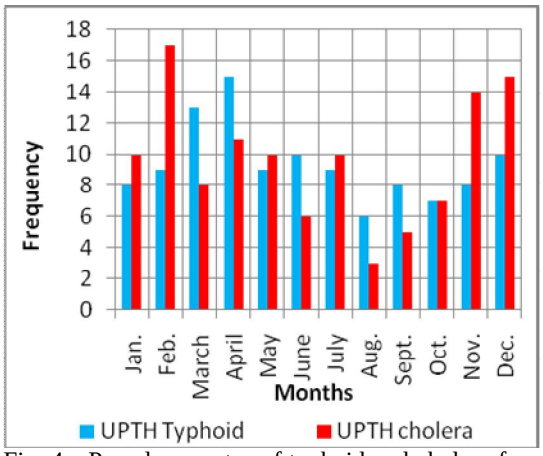

Fig. 4a: Prevalence rates of typhoid and cholera for UPTH by 1986.

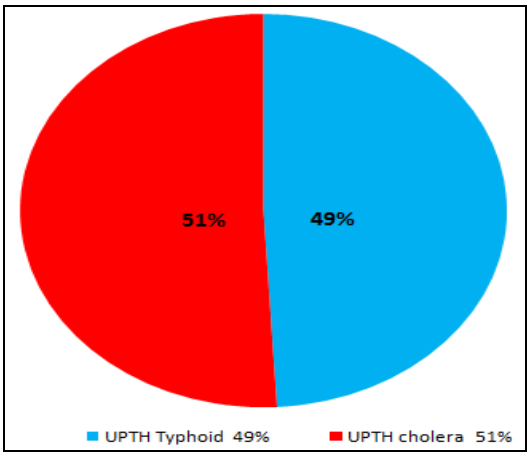

Fig. 4b: Annual percentage incidence rates of typhoid and cholera at UPTH for 1986.

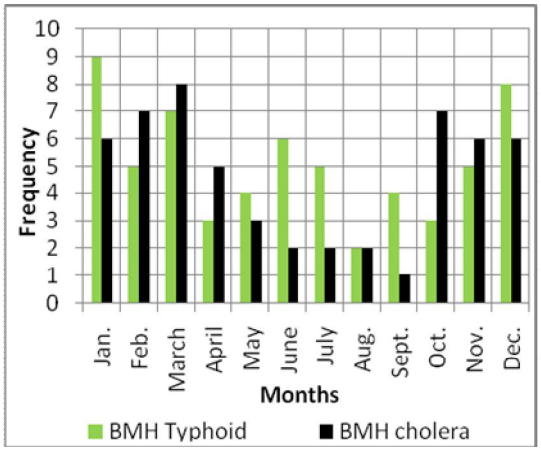

Fig. 5a: Prevalence rates of typhoid and cholera for BMH by 1986.

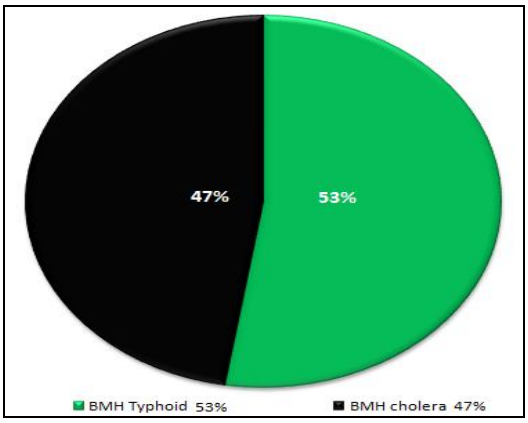

Fig. 5b: Annual percentage incidence rates of typhoid and cholera at BMH for 1986.

When water carriage/closet system was in use by 2010 as shown by Figs. 6a and 7a, the incidence rate of typhoid fever was very high while in most of the months, there was no incidence of cholera. The annual percentage distribution of the incidence rate of typhoid fever was 94% and cholera was 6% for both UPTH and BMH as shown by Figs. 6b and 7b respectively. Fig. 8 shows the Annual incidence rates of typhoid and cholera for both UPTH and BMH for 25years from 1986 – 2010. The Figure vividly shows that between 1986 and 1997 incidence rates of cholera was alarming, which was not unconnected to the sewage disposal methods (pit latrine, bucket latrine and pier latrine) of the time. However, from 1998 to 2010 incidence rate of cholera started declining while incidence rate of typhoid fever increases significantly. These trends coincided with the period of change of direct and conservancy sewage disposal methods to water carriage/closet systems.

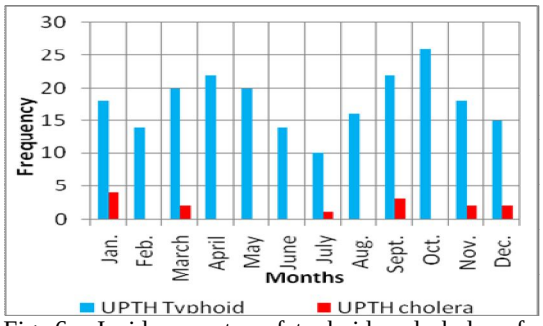

Fig. 6a: Incidence rates of typhoid and cholera for UPTH by 2010.

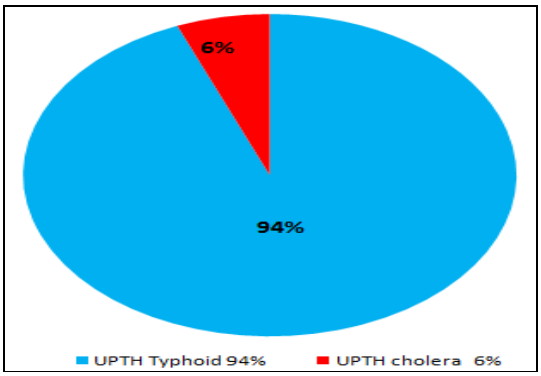

Fig. 6b: Annual percentage incidence rates of typhoid and cholera at UPTH for 2010.

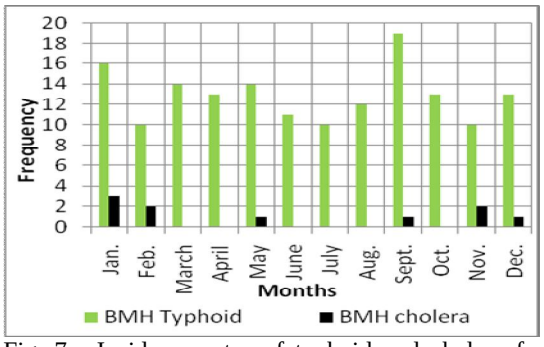

Fig. 7a: Incidence rates of typhoid and cholera for BMH by 2010.

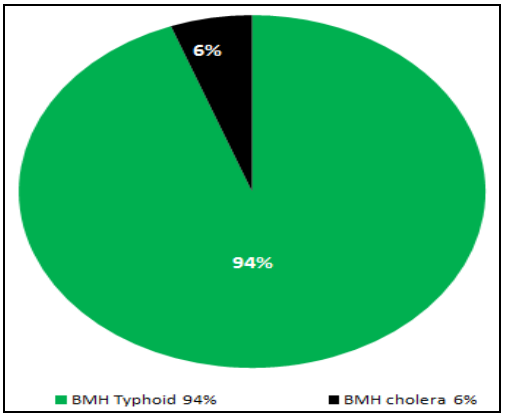

Fig. 7b: Annual percentage incidence rates of typhoid and cholera at BMH for 2010.

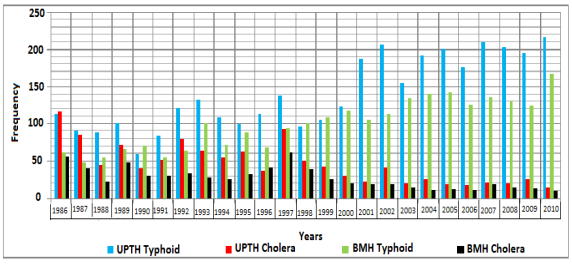

Fig.8: Annual incidence rates of typhoid and cholera for both UPTH and BMH from 1986 – 2010.

CONCLUSION

From the findings of this work with respect to the types of operational sewage disposal methods, and the incidence trends of typhoid fever and cholera as presented by Tables 1 and 2, and Figs. 4 to 8, and the coincidences of these incidence trends of typhoid fever and cholera with the different sewage disposal regimes, there is indeed a stronger correlation of higher incidence rates of cholera and a moderate incidence rates of typhoid to the period of pit latrine, bucket latrine and pier latrine (i.e. 1986 to 1997). While the incidence rates of cholera was minimal when water carriage /closet systems of sewage disposal was operational with a very high incidence rates of typhoid during this same period (i.e. 1998 to 2010). The recorded high incidence rates of typhoid may perhaps be influenced by other factors other than sewage disposal approach: awareness to visit health facilities to handling such cases, availability of more and sensitive diagnostic tools, and proper keeping of medical records.

RECOMMENDATIONS

Based on the findings and the conclusions reached, the following recommendations are made:

- Water carriage/closet systems of sewage disposal should be adopted in all premises.
- In the absence of sewer in the study area, septic tanks should be properly designed, constructed and maintained to avoid leakages and malfunctioning.
- Septic tanks should not be sited upstream of the direction of flow of a water body.
- Buffer distance between water supply sources to a septic tank or sewage disposal site should be within the permissive range.
- There should be high level awareness campaign and health education on sewage management, water sanitation, food hygiene and environmental sanitation.
- When infected, patients should visit government approved health facilities with qualified professionals for effective treatment to completely eliminate the causative agent.
- Government and relevant agencies should all collaborate to supplying portable water for the citizenry, which is a major prophylactic measure to these infections.

ACKNOWLEDGEMENTS

The authors are thankful to Mrs. Jane Iyeneomie and IYETAMS Ventures Nig. Ltd; for the proofreading and typesetting of this work. Our thanks also go to the departments of medical records and statistics of both UPTH and BMH; for making available the needed records to actualize this work.

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