ASSESSMENT OF HOUSEHOLD LIQUID WASTE MANAGEMENT A CASE STUDY OF ACCRA, GHANA

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(Received 18th February 2021; accepted 20th March 2021)

Abstract. The research undertook the performance of waste management systems in Accra which was categorized into four zones; i.e. the high income level, the middle income level, the low income areas and the slum in order to analyze the systems effectively. This is because installations of waste systems differ from various dwellings due to many factors such as economic factors, affordability, infrastructural availability, etc. From both secondary and primary data, the study added to the body of knowledge in management of wastewater treatment which has been described as complex as it deals with the provisions of amenities towards continuous human satisfaction. Household liquid waste management has been found through this research activity as an individual affair as there has not been enough documented literature available to guide the building industry. Another reason was the adoption of unapproved portable systems in the country; most are imported into the country freely and are being installed all over without the 'stamping' approval of any authorized body. The study however uncovered a few effective systems that have been functioning well in certain areas especially in lateritic soils and well serviced areas. Those systems were however not suitable in other areas without the same conditions as the treated liquid waste which should be discharged into a drain, etc., do not meet the EPA requirements for such purpose. The water then becomes stagnant thereby causing diarrheal diseases, etc. All these anomalies could be avoided with the introduction of routine workshops and short courses to train installers and interested parties in regular refresher courses.
Keywords: *liquid waste, waste management, flaws, performance, fecal matter*

Introduction

This research activity is centered mainly on management of household liquid waste treatment in Ghana using Accra as a case study. The study comprised of examination of the level of pollution of liquid waste being discharged into main drains compared to Environmental Protection Authority (EPA) and Ghana Standard Authority (GSA) acceptable Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels. A few communities in Accra were selected for this exercise. Accra was chosen as a case study because it comprises of all levels of communities namely, High income level, Middle and Low Income level residential areas, as well as the Slum which is popularly referred to as the Zongo community. The study of the existing management structure coupled to the procedures being carried out in some advanced countries in Europe could help in arriving at a proposal that could help improve the system. The research activity is very necessary as it could help alleviate possible pollution of water bodies in Ghana which are the main sources of potable water consumption. From developments in Ghana pollution of water bodies is mainly from discharge of untreated liquid wastes; i.e. aside from pollution from illegal mining, an exercise which can be tackled when National Security triggers their action plan.

Preliminary observations show that Accra is predominantly lying in a low terrain. i.e. below sea level. This creates frequent flooding when it faces heavy downpours. This makes effective gravitational flows of liquid waste into main drains a difficult task. This

compels many households to indulge in unacceptable liquid waste disposal into main drains as treated water would have to be released into some drains of some sort. The situation could be compounded if existing public drains do not flow into any treatment plant because there could be an outbreak of water borne diseases as a result which could jeopardize the lives of the people in the neighborhood. Every structure such as residential building, office building, hospital, factory, etc. produces some level of waste and hence the policy on liquid waste discharge must be clear and feasible. This would enable developers and dwellers to be more cooperative and go through laid down procedures to acquire the necessary permits in their developmental agenda. The study also provoked discussions on establishments that were mandated to ensure quick approvals when developers submit their plans. The researcher explored all possible reasons that might hinder citizens from obtaining permits. Some possible reasons obtained from the research include economic reasons in as much as institutions responsible for supervising and sanctioning of violators are ill-informed due to inexistence of training of personnel which is deemed to be of essence; knowledge in this environ is rare and hence it is not enhancing pragmatic approvals. This renders developers to adopt ad hoc measures in the course of duty. The reason being that when the facility is not available, it becomes worthless if one can subject developers to adopt an inexistent rule. This enables developers to strategize to scale through the approval processes which is not good for a developing nation such as Ghana. As such people endanger themselves especially during heavy downpours. Some areas looked at are the topography of the various localities, possible reasons why sewerage structures are not in existence in certain parts of Accra.

The Research Objectives are includes to study existing household liquid waste disposal systems in Ghana taking into account the diverse dwelling areas and their ways of disposal into public drains; as well as to discuss the most effective ways of handling household liquid wastes.

Literature review

Existing literature such as UNICEF (2016) and activities on household sewerage systems were used in order to create a reasonable and effective study worthy and acceptable by the reader. There are existing structures for the management of household liquid wastes which were used over the years with very little maintenance needed; even with the very little maintenance to be performed the works would not warrant shut downs during the activity. Such installations were considered worthy in this study which the Researcher explored to acquire enough information for his analysis on data that were acquired throughout the research activity. The research objectives arose from the fact that most of the high class areas which make use of a central sewerage system do not face perennial problems in any way. Such areas can have all the necessary plans as they may be capable of affording the revenue commensurate to the services offered. Preliminary investigations prove that management of the central sewerage system is difficult. As a result, some have broken down. The problem here is that dwellers cannot be stopped in any way from the usage even when the facility breaks down and becomes a difficult task at such times. Information from portable sewage systems was sought from notable and experienced companies operating in Ghana such as Anno Engineering Limited noted for biofilm digesters, Impact Environmental Limited and David Bio.

Review of existing research activities

Enough information was sought for and gathered from local authorities constitutionally mandated to inspect to ensure that dwellers and developers are abreast with laid down structures when it comes to disposing of household liquid wastes. Authorities could instill some level of discipline in collection of fees enough to keep the facility running; an important factor which when downplayed could run such an effective process rather into a disaster. The local metropolitan authorities have a task to deal with in order to overcome this. Types of liquid waste disposal system varies greatly from area to area and every household needs to present a design subject to approval by the authorities. Initial investigation reveals that the necessary designs in the various localities in Accra are not available. In this regard the authorities are not able to act quickly enough for this exercise as developers cannot wait longer than their planned developmental agenda for permits to be granted when they submit their plans for approval purposes. It disorientates their construction process. In this case authorities responsible for the approvals should display laid down processes that developers must follow and adhere to them. This would bring sanity into the built environment system and create smoothness in the planning of both the developers and the authorities.

Waste prevention as better waste management tool

Waste prevention as defined is "strict avoidance, reduction at source (e.g. home composting) and reuse for the product's original purpose" (Cox et al., 2010). This article on household waste prevention in which recycling was even excluded could be as a result of huge cost of installation and also difficulty in management when it comes to household usage as one small default could result in serious life threats as occurred in The King's County Wastewater Treatment System in Seattle in USA as per Mapes (2017). In this regard education of citizens to reduce wastage could serve as key in addressing many problems in the management aspect of the household liquid waste treatment systems. Volumes of wastewater generated per day could be greatly reduced if every household decides to manage the wastewater generated (Ministry of Local Government and Rural Development, 2010). This is possible through education and also through policy formulation. If every household decides to generate wastewater through their own terms without any legislation they would not bother whatever happens to them. This explains why there should be a policy in place to control this; through engineering and monitoring of waste disposal into public infrastructural systems to the requirement as purposed in the initial infrastructural design.

Materials and Methods

The research covered various areas in Accra by zoning them into economic income level of the community dwellers; the levels were, high level, middle income and slum which as explained earlier was due to affordability of sewerage systems and level of exposure which have been observed over the years as an issue when it comes to sewerage issues. The study also compared effects of sewerage systems in flood prone areas with water-borne diseases over the years. The areas considered were Labone, Teshie Nungua, Burma Camp, Kaneshie, Abeka, Achimota and Dansoman (*Figure 1*). Every area covered had its own peculiar problems all leading to the main drains which need upgrade of some sort. Infrastructure of the main Capital city of Ghana does not commensurate with the growth of the population. Quantitative data from the selected dwellers as well as the district assemblies were relied on for effective analysis as they

bordered on satisfaction or otherwise of the dwellers. The district assemblies on the other hand pinpointed all hindrances as well as possible deficiencies they face in their course of official duties. Quantitative data from the Consultants as described formed the main engineering analysis which the Researcher relied on to conclude on how current the systems in Accra Ghana are performing internationally. Questionnaires were given to selected dwellers depending on the areas in question. The dwellers in the high income level residential areas such as Labone, Cantonments and Airport West gave an uncompromising and elaborate systems with reasons pertaining to the shortfalls realized occasionally. On the existing central sewerage system which spans from parts of Cantonments, North Ridge, through the Ministries and some parts of Osu appear to be satisfied with the sewerage system which was recently replaced. Data from the interviews showed that they did not even realized that the system was broken down all those years they were in use. In the middle income areas, the survey considered Dansoman and Mataheko, The Bank of Ghana flats purported to be for the middle income level area was subjected to scrutiny. As workers of Bank of Ghana, the researcher found it very useful as the institution is deemed to be par excellence when it comes to personnel. The application of individual septic tank was evident however the soak away system was not subjected to any soil consideration as the blocks on the higher terrain were operating successfully whereas the lower terrain was faced with overflows into open drain especially during rainfall season. In the slum which are considered as "Zongo" most inhabitants were without toilet facilities and make do with public latrines. The slum normally consists of heavy population densities and as such long queues are realized at peak times in the morning. A policy of one house one WC has been announced but how it would be implemented is an issue.

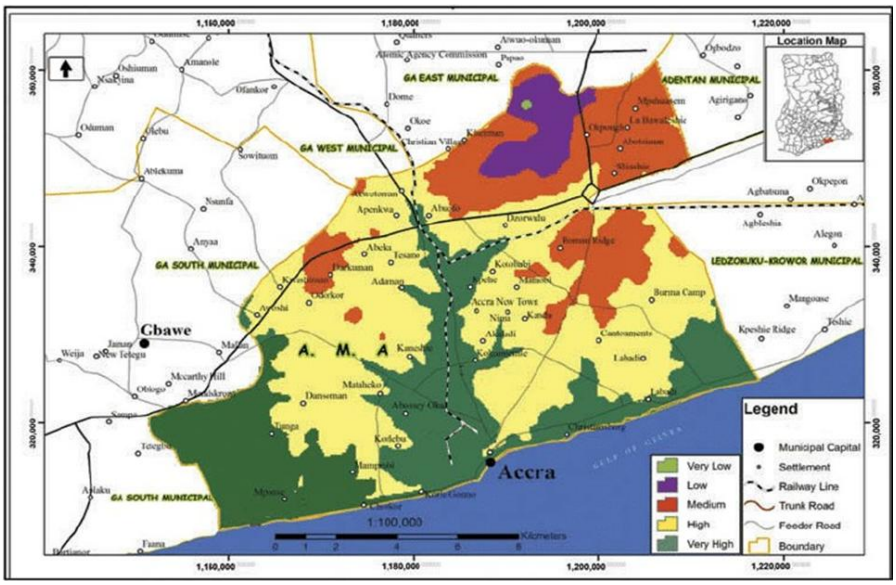

Figure 1. *Flood risk map of Accra Metropolitan Area (City of Accra). Sources: Centre for Remote Sensing and GIS (CERSGIS), University of Ghana, Accra (2013)*

Results and Discussion

Existing wastewater treatment systems

The sewerage system used in the La Dadekotopon Municipal Area (LADMA) is largely individual septic tanks with different kinds of soak-away systems for effluent disposal. The sewerage disposal for the Ghana International Trade Fair is central sewerage system where all black water from the various buildings were channeled into a Trickling Filter system comprising of a large open concrete tank with pumping stations for the various stages of treatment processes. The system is however damaged and greatly causing inconvenience to passersby. As a result of this the system needs to be replaced as it is still being used in its dysfunctional condition.

Labone Estates

The type of sewerage system used at the Labone Estates area which is an adjoining suburb is Activated Sludge which is also in a state of disrepair. The maintenance of the facility is managed by the Public Works Department (2003)

Burma Camp

Burma Camp is also facing similar situation as the existing Trickling System needs complete replacement. The maintenance of the facility is managed by the Public Works Department (2003).

Accra Mall

The initially designed and constructed sewage treatment system for the Accra Mall was affected by the Spintex Road development and had to be relocated to an area which was not initially demarcated for such purpose. Investigation made on the new system which is an activated sludge type showed that it has not been effective as it has been facing frequent breakdowns especially when the facility is heavily patronized during festivities. The facility comprises of a holding tank from which the pre-treated effluent is pumped into an activated sludge chamber where the biological oxygen demand (BOD) is attained for dislodgment into the main drain. From the total area capacity of 20,000m² a total staff population can be estimated at 2000. The sewerage generated from 2000 estimated at 10gallons/person/day works out to 90m³/day. For a total of 18,000 revelers and shoppers daily, the total volume of wastewater usage at 4gallons/person/day works out to $90m^3 + 72m^3 = 162m^3$ at peak season which includes Boxing Day, etc. The capacity expected for the Mall at its peak season is 162m³/day from the calculation above.

The existing treatment plant consists of a holding tank of capacity 75m³ which happens to be one half of expected capacity. A further investigation carried out on causes of such frequent breakdowns showed that there is inadequate capacity of grease interceptor from kitchens and other facilities that generate grease. This causes waxing of oil in the pipe and hinders flow of sewage as a result. This calls for effective flushing of grease periodically to attain effective flow of the sewerage into the treatment plant.

Labadi Beach hotel

The Package Plant system installed at the Labadi Beach Hotel is functional. This is managed by the hotel technical staff.

Kofi Annan International Peace Keeping Training Center

The Kofi Annan International Peace Keeping Center is equipped with a Package Plant comprising of the bioreactor system of several units buried and combined with phosphate removal of pathogens. This facility is functioning. The maintenance is carried out by the installers who signed an after-installation maintenance contract with the client.

The Ghana Police Depot

The Ghana Police Training Depot comprises of many buildings with various septic tanks positioned on a lower terrain with soak away systems. The septic tanks have not seen maintenance activities since they were constructed and have been found to be leaking all over with mal-functioning soak away systems. A contract had been awarded to an Israeli company to relocate them and improve upon the system with a more effective and modern designs at the time of this survey activity. The new system incorporates the usage of the Duraplast Septic Tank (DST) which comprises of a treatment plant filled with substances rich in coal with vent to help in the treatment of domestic wastewater. The outlet chamber receives periodic dosing with chlorine. A further investigation proved that the effluent from the system has been tried and tested by the Ghana Standards Board as suitable to be discharged into public drains.

Observation

The systems as narrated above are a selected few of existing liquid wastewater treatment facilities in Accra. In designing new systems, a cue should be taken from the occurrences and operational difficulties they undergo to create an environ for an effective completion and functionality in an acceptable manner. It was also observed that the systems that are maintained by the privately owned properties are functional; however the others maintained by the Public Works Department (PWD) were all broken down and in a state of disrepair. This would however be overcome on projects if the main component that enables the facility to run successfully, which are “Operation and Maintenance” (O&M) would not be compromised. Items such as grease interceptors, individual sewerage systems from the developers and other installations which would be required from various developers should be vetted by a body that would be mandated by the Engineering Council if the Government would empower them to function as such. This would enable them to ascertain the effectiveness of the system they propose to construct before approvals are given. In this regard the problems identified from the liquid waste disposal systems with the immediate surrounding areas would not be evident on projects. Even though the research activity did not delve much into the engineering design aspects of the decomposition of the faecal matter of the liquid wastes discharge it included the study of flows from some properties such as residential facilities, hostels and even high and low-rise offices. This completes the research activity as it would help the reader to understand the research article better with regard to the inputs acquired in arriving at logical conclusions (*Figure 2*).

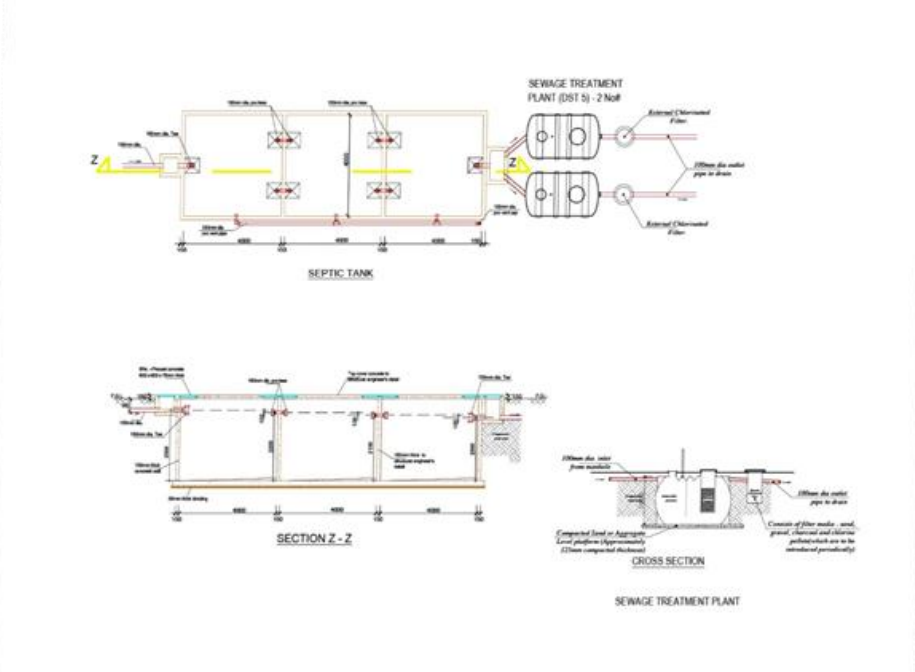

Figure 2. *Typical sewerage system found to be effective as derived by the researcher.*

Acceptable design consideration

The Sanitary Sewer Systems Design and Construction Manual (Public Works Department, 2003) was used in some analysis that were required in the research activity. It gave tentative flows per person and sizes of sewers that were used in the analysis where found necessary. Hall et al. (2004), a British textbook on Building Services was also fallen on when it came to application of acceptable parameters. This enabled the Researcher to gain the opportunity to combine the American Standard to the British Standard in the determination of acceptable standards in his analysis. This was seen necessary as a result of the variations in standards with the British style of determination of capacities and sizes less than the American Standard. Since both standards are dominating the sanitary appliances allowed in the country and acceptable internationally it was found to be necessary to consider both standards to attain a more successful implementation of the sizes and gradients as well as other parameters. Crimp and Bruges (1948) formula which is used to determine flows when dealing with Sewerage and Sewage Disposal and obtainable from *The Contractors' Record Limited* was used for quick checks in the comparison of pipe sizes once flows are determined. These were made on selected systems where the researcher gained access through colleague engineers and some few contractors on the projects. It was observed that most projects did not have standard MEP drawings especially plumbing and as such pipes had been either undersized or oversized. Such unprofessionalism should be avoided by developers as it makes running cost very high. For instance, the British System allows for 25mm diameter pipe to connect to 8No sanitary appliances. If a bigger pipe is used it shoots the water supply unnecessarily above the normal and hence more water is used instead. When probed into the reason why the Architectural Drawings were very well documented without the plumbing and other systems, it was explained that most clients normally give architects the initial contracts and as such expect them (the architects) to form their teams for such purposes. In that case the problems then arise from miscommunication. If such circumstances were not made known to the clients from the

beginning it would be difficult for them (clients) to expend some more monies to satisfy the other sub-works. The reason could be attributed to the fact that finances are normally sought for with cash flow plans before and during construction periods which are included in the planning. The researcher thus concluded that communication is a very important tool to be considered in aversion of project risks.

The Bio-fill digester technology

The bio-fill digester technology has been found to be effective however training is very important as any misapplication would rather endanger the lives of the users. Amoah et al. (2016) carried out a study to assess the efficacy of a standard bio-fil toilet digester with regard to its effluent quality and to evaluate the performance of treated effluent as developed by BiofilCom in Ghana. The results showed that "Escherichia coli and total coliform levels were significantly reduced by 63% and 95.6%, respectively, and nutrients were the least removed from effluents. Generally, effluents from the majority of the pilot polishing options met most of the discharge standards. E. coli were present in the soil at all study sites, except one. Biofil digester effluent is discharged subsurface but comparing their effluent quality with standards for discharge into water courses is relevant especially in areas of frequent flooding and high water tables." (Omani, 2015). The design is simple, replicable, and affordable. It operates on very low maintenance requirements. It is suitable for all soil conditions including heavy clay soils, shallow or exposed rock beds and soils with high water tables. The digester can be laid above ground or below ground depending on the groundwater level of the location. The digester operates as a filter via: Rapid separation of solids and liquids, Aerobic composting of solids and Bio-filtration of waste water For maximum sanitation effect, the Biofil Microflush Toilet System as per Amoah et al. (2016) is designed to integrate hand washing. The main drivers of the Biofil system Good sanitation practice Biofil Digester is completely aerobic. It requires minimum maintenance and needs no mechanical or electrical aeration of solid mass to achieve decomposition. There is no need for human contact with excreta. No odours or sludge are generated in the system to attract insects that spread germs. Design considerations of the system (digester made of concrete) make it impossible for rodents to burrow into Digester unlike conventional pit latrines (*Figure 3*).

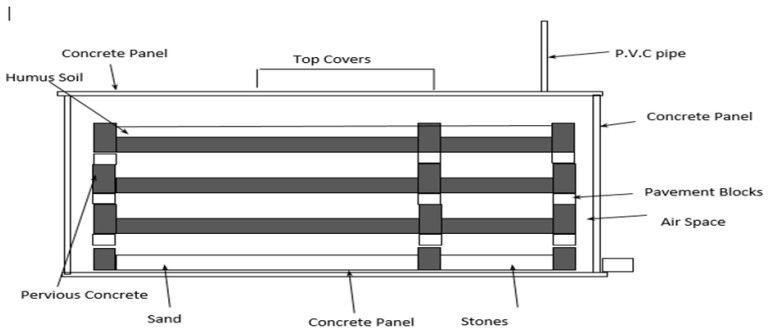

Figure 3. *Cross-section of Biofill digester system.*
Sources: Omani (2015)

Biogass technology

The biogas technology is a system which should be considered in any educational institution especially during the scoping processes. This is because of the rising costs of utilities every year especially in developing countries. Considering the availability of the raw materials in abundance it becomes worrying why such a facility should be pushed down the shelves during initial design considerations. Students are being overburdened with high hostel utility bills and this could be used to lessen them in many ways. The figure below explains how the biogas system works indicating the flow of the raw material through the simplistic procedures to the benefits which include the running of the kitchen services and electricity generation (*Figure 4*). There is yet another benefit which is predominantly for landscape purposes such as fertilizer and watering of plants. Biogas is the gas obtained from anaerobic digestion processes where the plant converts animal or human wastes into combustion gas as per the Biogas Portal (2019) In simplistic terms, the average calorific value of biogas is around 23MJ per cubic meter of biogas which is approximately 0.5litres of diesel fuel of about 6kWh (Arthur, 2019). This explains the reasons why the technology should not be down-played in the scoping process of hostels and other institutions to serve as cost reduction in utility tariff distribution to students, etc.

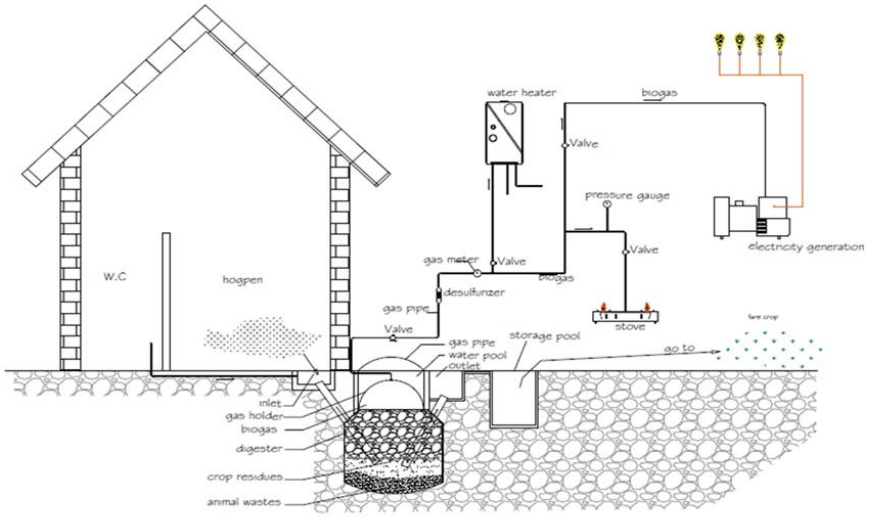

Figure 4. *Schematic of a Biogas used for power generation.*
Source: Biogas Portal (2016).

Grease traps

Grease traps have also been a subject to consider as realized from the Accra Mall example. This can be sized with the volumes of oil usage in the various kitchens in order to play safe as one may not know what happens during the cooking processes. Accidents may occur at any time no matter how careful the kitchen operators perform. The grease traps cannot be self-sustaining and documentations must be prepared to accompany the handing over manuals stating the periodic maintenance that may be required. This would reduce the effects of grease waxing in the pipes. In that case there would be no way the grease could flow into the pipe in order not to disturb the treatment processes aside impeding wastewater gravitational flows in the pipes (*Figure 5*).

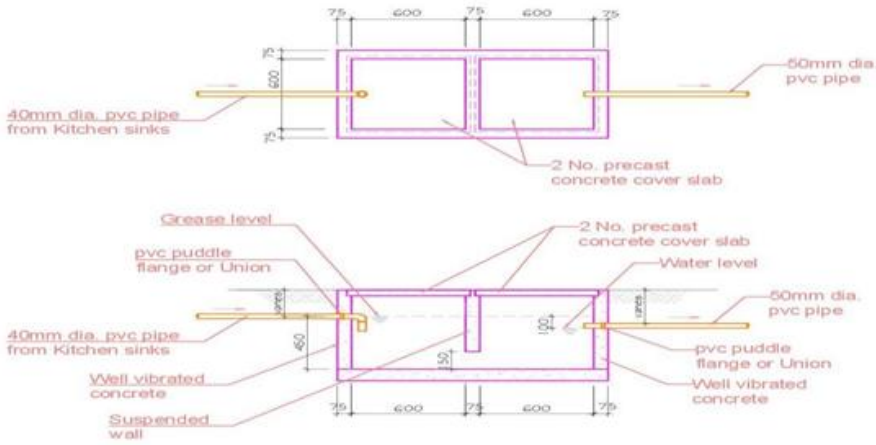

Figure 5. *Typical grease trap.*

Conclusion

With the above procedures, the Researcher conveniently arrived at acceptable conclusions in the Research activity which can be described as solid and relevant believing that the outcomes contribute significantly to enhance the household liquid waste management in Accra and largely Ghana. Many literatures were fallen on when it came to adoption of bio-gas system for cooking purposes, however none of the hostels visited are using them where they were needed most with regard to student population and kitchen services. It is worrying the way initial installation cost has always been the issue from the beginning not factoring the consequences as running cost is always high. Spending some few hundreds and thousands of Ghana Cedis on a system, would produce bio-gas for cooking as compared to purchasing liquefied petroleum gas is untenable. The DST system is produced in Ghana and the example adopted by the Ghana Police Depot where the system is used to replace the soak away system is very adequate. The government can subsidize the production or better still look at the reduction of taxes on the raw materials to enable residential property developers to purchase them in mass quantities; this can make the facility more affordable and open up the industry for competition to enable others to jump into the production of such items. Other systems such as the bio-fil digesters are being patronized in Accra however it was observed that most of the installers did not have adequate training and as such their systems are failing all over due to poor knowledge and expertise in the installation processes. They were rather looking at the economic aspects and giving it a stronger weight leaving the technical aspects to suffer the fate. They finish installing, collect their payments and leave the developers to their own fate. What does one expect if there are no constitutionally mandated bodies to check all these? Bio-fil digesters do not work effectively in water-logged areas unless instructions are carried out in such areas which require the system to be elevated above the water table. This must be made known to developers because if the installers do not follow the installation procedures to execute a functioning system it is worrying. The call on NADMO on the government to enforce strict laws to “punish people who litter and throw rubbish in main drains” is in order.

However, this can be effective if the people take this up by educating the citizenry on community basis. In effect it is the responsibility of every one to help.

Acknowledgement

The research studied was self-funded.

Conflict of Interest

The author confirm there are no conflict of interest with any parties involve in this research.

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