Domestic wastewater: characteristics and treatment

General

Generally domestic wastewater can be classified in two basic categories. These are brown wastewater (kitchen, bath, laundry) and the black wastewater (urine, faeces and toilet paper) (Ericson 2002). Based on classical wastewater studies, the influent characteristic wastewater can be summarized in three main categories (Metcalf & Eddy 2005). These are:

- Physical characteristics: The physical characteristics of wastewater include those items that can be detected using the physical senses and simple instrumentation. They are temperature, colour, odour, and solids.
- Chemical characteristics: The chemical characteristics of wastewater of special concern to the research are pH, dissolved oxygen (DO), oxygen demand, nutrients, and toxic substances.
- Biological characteristics: The three types of biological organisms present in wastewater are bacteria, viruses, and parasites.

According to Novotny (1989) the main objective of wastewater characterisation is to provide pertinent information on wastewater for the design on treatment process serve as a basis for effluent strength. Information on the nature of the wastewater is essential in order to design on-site wastewater treatment systems as the effluent quality depends upon the influent characteristics (Gross 2005). The efficiency of the treatment system respective to each wastewater quality parameters can be determined from the following equation after Mark (2004)

Where:

Cin = Influent concentration (typically mg/L)

Cout = Effluent concentration (typically mg/L)

And Efficiency is expressed as a percentage (%)

The above relation expresses that the efficiency of treatment is calculated based upon the influent concentrations and the effluent requirements. Hence, determination of the influent and effluent quality is essential.

The Influent Quality

The influent quality of raw sewage entering a septic tank is vary from one area to another, this depending on the living standards of the dwellers, the housing types and household activities (WRC 1990). Generally the solid waste content of raw domestic sewage is very low, averaging around 0. 1%. This normally comprises waste organic matter, some inorganic solids, heavy metals, sand & grit, and floating debris (Metcalf & Eddy 2004).

Wastewater also contains a range of bacteria and micro-organisms. Some are essential in the biological treatment process, while others can be harmful or disease causing. These are referred to as pathogenic bacteria, such as E. Coli and other common faecal coliforms (WRC 1990). The concentration of pathogenic bacteria present is normally used as an important indicator of wastewater pollution levels (WRC 1990).

The primary components of the incoming wastewater that will be of concern to the wastewater treatment facility design will be the:

- the concentration of oxidisable organic material, the BOD and COD

- the concentration of nutrients present, basically nitrogen and phosphorus
- the total suspended and setlable solids concentration

The Effluent Quality of the Onsite Small-Scale Treatment Units

Many research shows that the effluent quality of onsite treatment system with out polishing ranges 40%-60% depend on the type of treatment facility provided (Boller 1997, Tchobanoglous 1998, Wilderer 2005). Table 2 shows that typical septic tank effluent qulity based on literature and reports.

Table 2 shows that the recorded effluent quality in Ireland is lower than the other literature based values. This is because of two main reasons. The first one, the Ireland case is based on EPA 1998 synthesis report and the mean effluent quality of septic tanks from domestic sources. The samples collected from boreholes and the septic tank effluent believed passed through a secondary treatment (adsorption field). The second reason is in case of US the septic tank users used to have the kitchen garbage grinder and the influent organic loading is very high and it is reflected on effluent quality (US EPA 2002). Hence this can be the main reason for the variation of the effluent quality.

The difference in influent and effluent concentration indicates that a significant amount of pollutant reduction is taking place in septic tanks. However the efficiency figures indicate that the effluent needs more polishing to have the required amount of effluent quality.

The current Irish EPA code of practice mention the following standard effluent quality set for the purpose of declaring the test result of the performance of on-site wastewater unit some of the values are given blank

Wastewater flow rate

Among several design parameters the main design factor for wastewater treatment system is wastewater flow rate (loading rate). Septic tank volume, soil leaching systems, mound systems, and sand and artificial media bioreactors and similar fine media fixed film systems, their size and capacity determined based on wastewater flowrate (Zhou 2007). If loading is too high, these types of wastewater treatment systems tend to clog or fail. The main advantage of determining the flow rate of wastewater is to determine and design the size and capacity of the treatment units (Metcalf & Eddy 2004). The common values for design are the daily average wastewater flow rate and the long term variation in flow. In the case of individual house and small communities, the flow variation is very high and the peak factor (the design adjusting factor) depends on the number of people served by the system. According to some studies the peak factor may vary 1. 5 to 4. 0 (David et al 1999). The classical wastewater engineering books set the following expression to determine the ratio of peak and average hourly flow of wastewater.

Where : Qp = peak hourly flow

Qa = average hourly flow

P = population equivalent

Based on the current EPA code of practice the total design wastewater load should be established from the maximum number of people dwelling in the house, based on number and size of bedrooms. In order to calculate wastewater capacities, a typical daily hydraulic loading of 150 l/person/day should be used to ensure that adequate treatment is provided (EPA 2009). In the case of USA the average daily flow of waste water is approximately 189-265 l/person/day. For design purpose 260l/peson/day is considered (US EPA 2002). In case of most wastewater treatment plant design in deferent countries the flow rate can be taken as 85%-95% of the average water consumption rate (Mara 2004).

Organic loading rate is also an important parameter to determine the size and efficiency of the treatment unit. It can be presented as the weight of organic matter per day applied over a surface area, such as mg BOD per day per meter. The BOD5 is a measure of the oxygen needed to degrade organic matter dissolved in the wastewater over 5 days. It is reported as mg/l of oxygen consumed to degrade the wastewater in 5 days (Metcalf & Eddy 2004). BOD 5 is one way to measure the amount of easily degradable organic matter in sewage. To calculate organic loading rate the following expression is used (Zhou 2007).

Where: OLR = Organic Loading Rate

HL= Hydraulic Loading (150l/c/day in case of Ireland Ireland)

PE= Population Equivalent (10 in case of Ireland)

A= area

Environmental Impact of the Current Small Scale Treatment Units

The main impact of septic tank on the environment can be caused in two ways. The first is improper installation and construction of septic tanks and the second one is the failure of drain fields (Carroll 2006). When the septic tank fails, settled solid decomposition will decrease and the sludge volume will increase. This causes the transport of sludge particles to the drain field. Transported sludge particles may cause clog and plug of the drain field and infiltration to the ground water will occur (Smith 2009). The failure of the drain field causes the back flow of wastewater to the house. Moreover the untreated wastewater can bubble up to the soil surface, resulting in odours and possible health hazards (Smith 2009).

Geological Survey of Ireland GSI (2004) report states that about 30% of ground water endanger of poor functioning septic tank and failed drain field related contamination. In United States also the septic tank soil absorption systems failure is the second major cause of water resource contamination (Carroll 2006, US EPA 1997). Moreover it is reported that in United States 10%-20% of septic tanks are not functioning properly (Smith, 2009). Hence it is believed that the risk of pollution to groundwater and surface water related to septic tank and drain field failure is significant and frequently reported as cause of water resource contamination (Carol 2006, Nicosia 2001, US EPA 1997, Yates 1985). For instance, the 1999 hepatitis outbreak in Australia occurred after the peoples consuming shellfish from Lake Wallis, which was contaminated with sewage effluent. Later the research found that failed septic tanks and soil adsorption system in lake vicinity contributed to the contamination. This shows that not only the groundwater but also the surface water is in danger.

The severity level of groundwater contamination also depends on the density of septic tanks. Some research studies shows that the spatial density of the septic tanks is directly related with the contamination level of groundwater resources (Yates 1985, GSI 2004). Moreover the risk of contamination also directly related with probability of failure of the systems (Ganolius 1994 and Carroll 2006). It is expressed by the following simple relation:

Where: L= Pollutant loading on the system (organic content, nutrient, microorganisms)

R = the system resistance (the amount of pollutant removed by the system before it failed or treatment efficiency).