TECHNICAL NOTE

Evaluation of sites for on-site sanitation systems

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Synopsis

In 1982 the National Building Research Institute (NBRI) of the CSIR embarked on a project to investigate the provision of appropriate technology engineering services for low-cost housing. Up to then very little research into site criteria for on-site sanitation systems other than septic tank systems had been done anywhere. However, engineers often need such criteria. The specific site criteria proposed in this article should be applied with caution, as they are intended only as an indication of the suitability of the terrain for on-site sanitation systems.

Samevatting

Die NBNI van die WNNR het in 1982 begin met 'n projek wat dit ten doel gehad het om ondersoek in te stel na die voorsiening van toepaslike tegnologie-ingenieursdienste vir lae-inkomste behuising. Tot dan toe was daar baie min navorsing wêreldwyd gedoen oor grondvereistes ten opsigte van op-erf sanitasiedienste anders as septiese tenkstelsels. Die spesifieke terreinvereistes wat in hierdie artikel voorgestel word, moet met versigtigheid toegepas word omdat dit slegs 'n aanduiding gee van die moontlike geskiktheid van die terrein vir op-erf sanitasiedienste.

Introduction

The cheapest sanitation system is usually some form of a pit latrine. However, some site conditions may prohibit the use of conventional ventilated pit latrines and other systems may need to be considered. Such conditions include the following:

- Sites with very shallow groundwater tables.
- Sites with impermeable soils or with a shallow restrictive layer, such as bedrock.

The permeability of the soil may affect the operation of on-site sanitation systems and systems therefore have to be designed to overcome such restrictions.

A proper site evaluation is fundamental to the process of system selection and design. The primary criterion for the suitability of a site is the protection of both public health and the environment. Cost and other criteria are secondary.

Sanitation systems

There are basically two types of on-site sanitation systems — those using water and those that do not.

Wet systems (water added)

- Septic tank systems with soakaways

Semi-dry systems (some water added)

- Aqua privies with soakaways
- Pit latrines equipped with tipping trays or pour-flush pans
- Biogas systems

Dry systems (human waste treated in loco)

- Pit latrines
- Anaerobic digester systems with soakaways

Dry systems (human waste not treated in loco)

- Bucket system
- Vault systems
- Biological toilets

Topographical evaulation

A visual survey of the site should be made and all features that might affect the proposed system should be noted and marked on the site plan. Such features include the following:

- The location of depressions, gullies, rocks or rock outcrops, water sources and other obvious land features.
- The type and degree of slopes.
- Surface and subsurface drainage patterns.

Obvious flood hazards should be identified so that sanitation systems can be designed to avoid them. Steep slopes may cause improperly treated effluent to surface during high rainfall, especially if an impermeable soil layer underlies a permeable layer. The problem is often worse in hilly areas where cut and fill construction techniques are used. In general, hilltops and side slopes have better drainage than depressions and foot slopes.

The vegetation on site often reflects soil drainage characteristics.

Soil profile and soil property investigation

A soil profile investigation should be carried out and soil properties, such as texture and structure, determined. Sampling holes should extend to a depth of at least 1 m below the bottom of proposed pits of pit latrines or below the bottom of proposed soakaways. The following should be noted:

- The depth to and the type of limiting zone encountered, such as bedrock, gravel, groundwater or a slowly permeable soil layer.
- The depth to and properties of identifiable soil layers.

The depth to the seasonal groundwater table is one of the most important factors, as it may affect effluent percolation rates and allow groundwater pollution. Soil mottling indicates the presence of high seasonal groundwater tables. In soils with restricted drainage, grey, yellow, red and brown colours are intermingled, giving the soil a multi-coloured effect. Care must be taken with the assessment, as organic matter may mask colours.

Poor and very poorly drained soil can usually be identified by thick and very dark surface soil and dark-grey subsoil, often nearly uniformly grey. A uniform bright, usually brown or yellowish-brown subsoil indicates that a soil is moderately to very well drained.

Percolative capacity of the site

The percolation test is designed to quantify the movement of liquids in the soil at a specific time of the year. Percolation rates usually change as the soil moisture content changes, and it is best to conduct the test in the rainy season. The percolation test should be regarded only as an indication of the suitability of the soil for a specific sanitation system. The following procedure should be followed:

Number of test holes

The number of test holes needed is affected by the size of the township and by the variability of the soil conditions. Usually test holes should be

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spaced uniformly throughout the area, at the rate of five to 10 holes per hectare, if soil conditions are fairly homogeneous.

Preparation

To prepare the percolation test holes, the topsoil layer should be removed to a depth of 500 mm. Test holes should have a diameter of 150 mm or should be 150 mm square. A spade or hand auger can be used. Test holes should be 300 mm deep and the surface of each hole should be thoroughly scarified with a sharp pointed instrument in order to remove unnatural (such as smeared) soil surfaces. Holes should then be lined with a polyester filter fabric and the bottom of each covered with a 50 mm layer of pea-sized gravel. This is to protect the surface from being scoured when water is added.

Presoaking

The test hole should be filled with clean water to a depth of 300 mm above the gravel and this level should be maintained for at least eight hours prior to percolation measurements. Automatic siphons or float valves may be employed for this purpose. It may be difficult to maintain the water level in coarse, sandy soils and in such cases it is only necessary to fill the hole twice to a depth of 300 mm above the gravel. The percolation test should immediately follow presoaking.

Percolation test

After the initial presoaking, the level of the water above the gravel should be allowed to drop to 180 mm, and from this point onwards the percolation rate should be measured. The drop in the water level should be measured at selected, constant intervals of between five and 60 minutes. A greater interval should be chosen as the percolation rate decreases. If the depth of the water above the gravel decreases to 130 mm, water should be added in order to return this depth to 180 mm while measurements continue. The test should continue until the drop in water level for two successive time intervals does not vary more than 10 per cent.

The percolation rate is calculated for each test hole by dividing the magnitude of the last drop in water level by the time taken, and this rate is expressed in millimetres per hour. The average percolation rate for the site (or parts of the site) should be calculated using the geometric mean method (the n-th root of the product of n-measured rates).

Suitability of the site

The values given below should serve only as a guide, in order to decide whether soil conditions are suitable for a specific sanitation system.

A percolation rate of ≥1 000 mm/hour

Any on-site sanitation system may be considered, but special attention should be given to the possible pollution of groundwater. It is recommended that the sand or gravel layer at the bottom of pits or soakaways be replaced with a 600 mm thick layer of loamy sand to enhance purification.

A percolation rate of 300 to 1 000 mm/hour

Any on-site sanitation system may be considered, but possible pollution of groundwater should not be overlooked.

A percolation rate of 100 to 300 mm/hour

Any on-site sanitation systems may be suitable; however, sites should be individually evaluated for septic tanks.

A percolation rate of 25 to 100 mm/hour

Such sites may not be suitable for septic tank systems, especially if the sites are small.

A percolation rate of 15 to 25 mm/hour

Suitable for all sanitation systems other than septic tank systems.

A percolation rate of 8 to 15 mm/hour

Suitable for all dry sanitation systems, or possibly for semi-dry systems.

A percolation rate of ≤8 mm/hour

Not all liquids may seep into the soil and therefore the site is unsuitable for systems requiring soakaways. Pit latrines may function not as dry, but as wet, systems. More frequent emptying of such pits may be necessary in some cases.

Pollution and on-site sanitation systems

Basically, two routes exist along which pollution may take place. The first route is the surfacing of partly treated effluent and the second is the passage of pollutants downward to the groundwater.

The first route should be prevented by all possible means, because the surfacing of partially treated liquids creates a direct health hazard. Fortunately, this type of pollution is not common and can usually be predicted. It is most likely to occur in areas where the groundwater table is very shallow or on sites with steep slopes where a shallow, permeable layer of topsoil covers an impermeable subsoil. In areas where cut-and-fill construction techniques have been used to provide housing sites, sanitation units should be carefully sited in order to minimize the chance of such pollution.

The second route of pollution is the one most frequently encountered and it is therefore necessary to assess the risks involved. The sensitivity of the site to pollution and the severity of contamination are two risk factors needing consideration. Site sensitivity determines the susceptibility of a site to groundwater pollution and includes matters such as public water sources (distances, numbers, usage and depth), the depth to the seasonal groundwater table, the soil permeability, soil types and the groundwater flow gradient. Contamination severity depends on the type of pollutant and the extent of the pollution.

Generally, the susceptibility of a water source to pollution decreases quite sharply with increasing distance from the source of pollution and increasing depth, except in areas with fissured rocks, limestone or very coarse soils.

In areas where groundwater is used for household purposes, certain guidelines apply:

1. Sanitation systems should, if possible, be located downhill of the water source.
2. Where an uphill location cannot be avoided, sanitation systems should be located at least —
   a) 15 m from the water source if the water table is quite shallow (ie 1,0 m to 5,0 m below the bottom surface of the pit or soakaway);
   b) 30 m from the water source if the water table is very shallow;
   c) 7,5 m from the water source if the highest seasonal water table is more than 5 m below the bottom surface.

The above criteria are not applicable to areas having fissured rock, limestone or very coarse subsoils. In fact, there is no safe distance applicable to such areas.

Conclusion

It is always very difficult, if not impossible, to lay down rigid criteria for deciding whether a site is suitable for a specific on-site sanitation system or not. This is because soil and site conditions can vary from one extreme to the other. With a wet sanitation system such as a septic tank, the percolative capacity of the soil is usually the primary limiting factor and pollution of groundwater only secondary. With dry sanitation systems such as pit latrines, the percolative capacity of the soil is seldom a problem and pollution becomes the primary limiting factor. Unfortunately very little research has been done in this regard and long-term studies are called for.

References

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