SHORT-TERM VARIATIONS IN WASTEWATER FLOW RATES AND POLLUTANTS FROM INDIVIDUAL RESIDENCES IN A REMOTE ABORIGINAL COMMUNITY

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Abstract

The characteristics of wastewater generated from individual residences are quite variable and unpredictable. This paper highlights the short-term variations in water quantity and quality in a remote Central Australian Aboriginal community. The principal factors for these variations and their implications on the performance of individual septic tanks in the community are discussed.

The results indicate quite different patterns to those observed in urban areas. The variations in pollutant levels did not follow the wastewater flow rates. The hydraulic loading rates into the septic tanks were found to be 2-5 times greater than those expected in urban areas and only one peak was observed in 3 out of 6 sites. Also, the hourly variation of the septic tank influent's total solids and biochemical oxygen demand concentrations exceeded their average values found in the literature by 2-3 times.

The paper highlights the implications of these variations on the performance of existing septic tank systems.

Keywords

Aboriginal communities, septic tank, performance, wastewater, quantity and quality, short-term variations, diurnal variations, biochemical oxygen demand

1 Introduction

Septic tanks are used by 31% of the remote Aboriginal population (Marshall, 1998). These are often called conventional septic tank systems (CSTS) where soil-absorption systems or soakage trenches are used for further treatment/disposal of septic tank effluent. In these communities, CSTS are known to be vulnerable to a high failure rate of around 60% and ongoing maintenance costs (Pholeros et al., 1993).

Due to public and environmental health concerns and ongoing increased maintenance costs, Nganampa Health Council (NHC), Alice Springs, commissioned a thorough investigation in 1995. This was primarily to identify why the systems fail and to provide control measures. Pipalyatjara, a remote Aboriginal community located within the Anangu Pitjantjatjara, (AP) Lands, was chosen for this investigation. One of the objectives of this work, completed in 1999, was to monitor water use and characteristics of wastewater generated from six households. This paper discusses the diurnal variations of wastewater flow rates and pollutants (ie, solids and organic matter) and their likely impact on the performance of septic tanks and absorption systems. Other results are given in Khalifé (2000).

2 Methodology

The six houses chosen appeared to have continuous occupancy record and required the least amount of preparation work. Water meters were installed at various plumbing fixtures at each of the six houses and readings were taken every 4 hours.

A water quality laboratory was established on-site due to the extensive sampling, testing and analysis involved. Each of the six sites was monitored at different sampling points. Black and grey water sampling ports, installed particularly for this study, were grab-sampled at 4 hourly intervals 24 hours a day. Effluent samples were made of composite samples.

Sampling at each site was carried out over a 3-day period, repeated every 7 to 9 days with a total of 8 rounds per site. Day 1 was set for composite sampling of septic tank effluent, and days 2 and 3 were set for sampling raw influent.

3 Results and Discussions

The results are discussed below under three categories: (i) design population load, (ii) influent water quality, and iii) diurnal variations in wastewater quantity and quality.

3.1 Design Population Load

Diurnal variations of wastewater quantity and quality are generally influenced by the daily occupancy, patterns of householders and their activities. These can be quite different in remote Aboriginal communities, due to the mobility of community members between houses during the survey period, and cultural activities (eg: family members and particularly children may not necessarily sleep in the same house as their parents, occupants may go hunting, attend ceremonies, football matches, or may be required to leave their houses following a death of a community member). Overall, an average of 10 occupants per household was found in this study. This considerably higher than that reported by Pholeros et al. (1993) and NHC et al. (1987). It should be noted that a population of 6 per household (SAHC, 1995) is currently used in sizing a wastewater treatment facility in remote Aboriginal communities.

3.2 Influent water quality

The influent black and grey water samples were analysed individually for the various wastewater quality parameters given in Table 1. Pollutant concentrations were then flow weighted and the characteristics of the combined influent wastewater for each of the six sites were determined. The results, generated between Nov. 95 and Feb. 99, are summarised in Table 1.

3.3 Diurnal Variations in Wastewater Quantity and Quality

Diurnal Variations in Wastewater Quantity

There were significant variations between the recorded water consumption rates and that reported by Pholeros et al. (1993). Overall, an average water consumption of 247 L/capita.d was observed and is found to be similar to the expected usage in an urban household.

The average wastewater generation rate per capita was 103 L/capita.d for a combined wastewater stream, and for black and grey water, segregated streams were 12 and 91 L/capita.d respectively. The combined wastewater stream was below the 47% conversion rate (wastewater flow as percentage of total water consumption) often predicted in urban areas. Also, the grey water generation rates were 20% higher than those reported by Jeppesen and Solley (1994).

Due to considerable variations and fluctuations in the water consumption and wastewater generation rates, the design flow was statistically determined, taking into consideration the wastewater flow distribution during the monitoring period.

Calculations were made in such a way that the design flow rate is greater than or equal to the daily average flow for 85% of time. This flow, estimated at 163 L/capita.d, was found to be higher than the 150 L/capita.d specified by SAHC (1995) for sizing a septic tank.

Table 1: Combined Influent Wastewater Quality

Combined influent	Site						Average	Typical (*)		
	1	2	3	4	5	6				
Flow, L/d	940	1469	455	896	797	954	919		-	
pH	7.7	7.2	7.6	7.8	7.1	7.4	7.5	5	-	8
Temp, ^{o}C	29	28	29	29	31	29	29	25	-	35
EC, µs/cm	-	-	-	1419	1200	1355	1325		-	
DO, mg/L	0.5	0.8	1.2	2.7	0.9	2.1	1.4		-	
Turbidity, FTU	399	376	386	295	271	1239	494		-	
SS, mg/L	339	434	412	382	387	809	461	240	-	600
TS, mg/L	1920	2008	2400	1932	1748	3595	2267	350	-	1200
TDS, mg/L	1570	1574	1988	1550	1361	2786	1805	250	-	850
BOD_5, mg/L	556	719	746	725	795	1048	765	216	-	540
COD, mg/L	1207	1378	1345	1417	1360	3881	1765	250	-	1000
COD/BOD	2.2	1.9	1.8	2.0	1.7	3.7	2.2		-	
Nitrate (NO-3 - N) , mg/L	7.0	7.0	4.0	4.9	6.3	4.4	5.6		-	
Nitrite (NO-2 - N) , mg/L	13.4	10.9	13.7	7.2	7.2	7.2	9.9		1.0	
Total Phosphorus (P), mg/L	-	-	-	4.5	4.1	4.3	4.3		-	
Surfactant, mg/L	0.1	0.2	0.3	0.6	1.6	-	0.6		-	
Oil , mg/L	16.4	35.0	26.7	2.4	12.1	4.3	16.1		-	
Faecal coliform 10^6 cfu/100mL	55	70	71	35	75	35	57	10	-	10^4

Note: * - Expected wastewater constituent concentrations from individual residences (Metcalf and Eddy Inc., 1991).

The diurnal pattern of hourly wastewater flow, as shown in Figure 1, exhibited two peak flows in 3 out of 6 sites. However, the average flow of all sites exhibited a single peak flow, occurring between 1:00pm and 5:00pm. This pattern is different from that of non-Aboriginal communities or urban household, where the first and second peak flows are expected during the early morning hours and in the evening between 7:00pm and 9:00pm (Metcalf and Eddy Inc., 1991), respectively.

The peaking factor, being the ratio of maximum to average wastewater flow rates, was around 3.2 and well within the range of 2-6 expected for flows from individual residences.

Diurnal Variations in Wastewater Quality

Similar to the variation in wastewater quantity, pollutants concentrations discharged from septic tanks varied with the time of day and the activities of occupants. The results showed that the peak influent SS and BOD exceeded their average values by 2-3 times with the variations in SS, TS, and BOD generally not following (or parallel) to the flow variations. Although influent SS was almost within the typical range of 240 - 600 mg/L, both TS and BOD levels, as in Figures 2 and 3, were outside (higher side) their typical range of 350 -1200 mg/L and 216 - 540 mg/L, respectively.

Unlike urban households where the peak BOD is expected around 9:00pm, the peak BOD concentration occurred (Figure 3) in the morning between 5:00am and 9:00am. These short-term variation patterns reflect the daily activities of residents. Generally, the concentration of pollutant decreases as the wastewater flow increases, due to dilution effects.

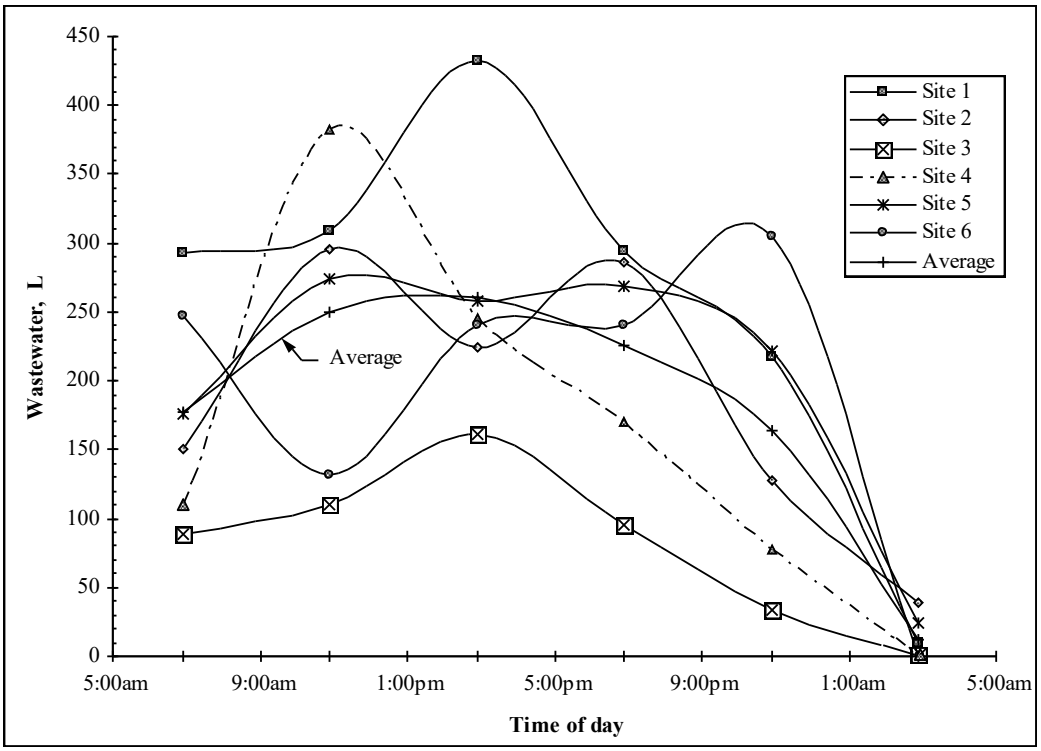

Figure 1: Hourly Variation in Domestic Wastewater Flow Rates

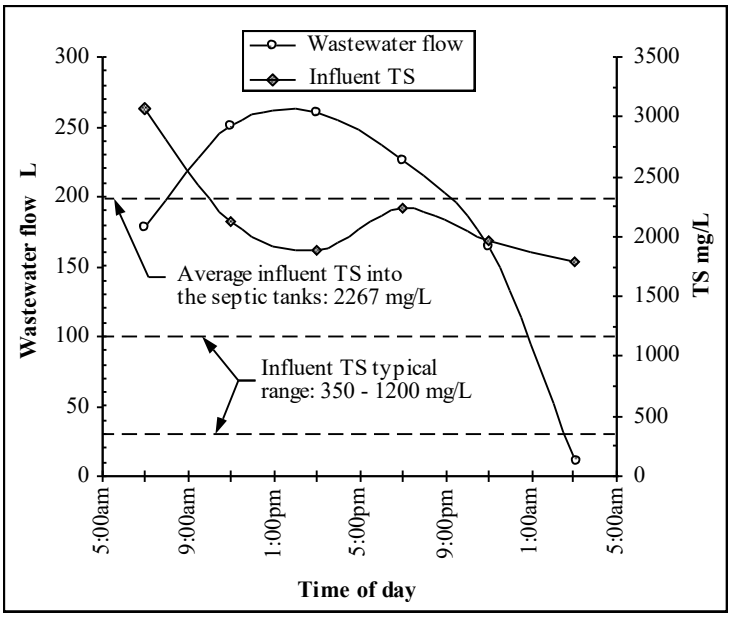

Figure 2: Hourly Variation in Total Suspended Solids

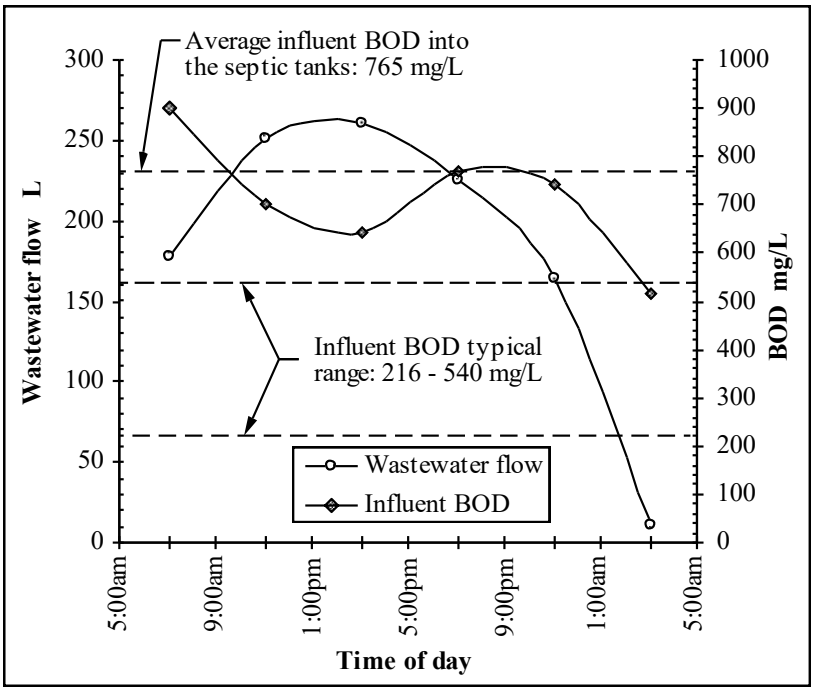

Figure 3: Hourly Variation in Influent Biochemical Oxygen Demand

4 Conclusions

The results indicated hydraulic, solids and organic overloading of the septic tank systems. Influent concentrations (Table 1) were generally higher than those for municipal effluent with organic loading rate 2 times higher than typical BOD values for urban areas.

The hydraulic loading rates into the septic tanks were 2-5 times the wastewater flow expected from a household in urban communities. However, the ratio of wastewater produced to water consumption was slightly less than that of urban communities. For design purposes, the study indicated that flow rates of 163 and 146 L/capita.d can be adopted in sizing future CSTS and greywater systems, respectively. In addition, an occupancy rate of 10 per household was found to be more appropriate in sizing a wastewater treatment facility.

Generally, the flow path of wastewater within the septic tanks, measured from inlet to outlet, and the partitioning are presumed to provide hydraulic buffering against the diurnal variations in wastewater quantity and quality. Furthermore, soakage trenches downstream from the septic tanks and the soil absorption systems may have sufficient storage capacity to handle above average hourly flow rates, mainly occurring in this case in the late afternoon. Consequently, the diurnal variations may only impair the performance of septic tanks and disposal systems if these installations are originally undersized. This is further investigated in Khalifé (2000).

Acknowledgments

The authors wish to thank Pipalyatjara householders and other community members and staff for their support, the Aboriginal and Torres Strait Islanders Commission (ATSIC) for funding this project, and Nganampa Health Council (NHC) for project coordination. Particularly, the authors wish to express their sincere thanks to Mr. Stephan Rainow and Mr. Paul Pholeros of NHC and the South Australian Health Commission for all their help and support during the project.

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