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Management of Carwash Waste in Urban Settlement

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ABSTRACT

Car washing is among businesses that erupted recently in urban Tanzania. The business in many areas has been done informally and hence not fully regulated polluting receiving environments. Results show solid waste and wastewater in the selected carwashes were predominant waste (25,732.5 kg/yr and 9,415,540 l/yr, respectively). Management of solid wastes were through collection, storage and transfer by trucks to municipal disposal sites. While wastewater discharge in municipal sewerage systems, onsite collection tanks, on soil and/or into water bodies. Wastewater management mechanisms were environmentally unfriendly. Henceforth, the study recommended upgrading hybrid carwash facility by introducing hydroponic vertiver grass cultivation

Introduction

Waste management is one of the intermittent challenges facing many countries of the world [12]. The ultimately ends of these are serious pollution of soil, air and waterbodies. In some cases, the problems are localized but sometimes the pollution cross boundaries and become potential cause of conflicts [13]. Increase of technology including industrial activities and road construction are among the culprits that have resulted to generation of waste which can be transferred away from the place of generation to nearby environments [12]. Rapid expansion of city boundaries especially in developing countries where business districts are far from residential areas, unreliable public transport, easy access to vehicles condemned in developed countries, and change in life styles have forced many dwellers to own vehicles that also became source of pollution. This is also attributed by the fact that in developing countries, many roads are not tarmacked, vehicles are therefore exposed to dusts. Hence requiring frequent washing to remove dust or mud, keep clean and further increase their life span [23]. This has resulted to mush rooming of carwashes in many areas of developing countries.

There are of various types of carwash facilities which are grouped into professional and traditional carwash. Professional carwashes are of three common types namely self-service, in-bay automatic and conveyor carwashes [3]; [8]. These carwashes seek to lower amount of water used and water discharged through water reclamation systems. Also tend to treat wastewater before discharge so as to minimize environmental deterioration [4]. Whereas traditional carwashes are of two types namely hand wash and wand wash. They are regarded as traditional because they haphazardly dispose waste from carwash facilities posing risks to the environment [2]. Different developed countries including USA, Canada, Switzerland, German and Netherlands have encouraged citizen to use professional carwashes so as to protect the environment especially water bodies [5].

While in developing countries including Ghana and Zimbabwe traditional carwashes are blooming at a high rate along river banks [1]; [2]; [14].

Generally, carwashes generate both liquid and solid pollutants which affect the immediate environment. A carwash facility can generate high amount of wastewater approximately 150 to 350 litres per day being released in the environment [6]. The wastewaters from carwash facilities are reported to contain various types of contaminants such as oil and grease, suspended solids, surfactants, detergents, heavy metals and hydrocarbons which are toxic to aquatic and terrestrial organisms leading to ecological imbalances. These toxicity effects include inhibition of plant and animal growth, mutagenic and carcinogenic to humans [21]. Apart from wastewater, carwash facilities also generate solid waste, in which sludge is the most important solid waste. Whereas other types of solid waste in carwash facilities include plastics and empty containers of chemicals and detergents, brushes sponges and worn-out clothes [14]. These wastes are associated with several environmental problems including blockage of gutters and drains, breeding stations for disease vectors and emission of toxic gases when burned with other waste [19].

In Tanzania, estimates show that about 1,010,732 cars were registered between 2003 and 2011 [11]. The increase also resulted into growing number of car washing facilities [1]. Current estimates indicate that number of vehicles in Tanzania is still increasing, hence number of carwashes is as well increasing yet there are no proper records available for carwash facilities and measures in place to avoid negative environmental impacts. Therefore, there was a need to assess management of carwash waste in urban settlements so as to create awareness on its environmental and health impact.

Material and methods

Study Area Description

The study was carried out in Dar es Salaam city, Tanzania. The city has four main rivers namely Mpiji;

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Msimbazi, Mzinga, and Kizinga River transporting storm water across the city to the Indian Ocean. Three of these rivers (Msimbazi, Mzinga and Kizinga River) are heavily degraded as a result of encroachment, erosion and sedimentation, wastewater effluents and runoff, and solid waste dumping [18]. Based on the 2012 Census, Dar es Salaam has a population of approximately 4.36 million people at a density of 3,133 per km^2. The future population projections for the city suggest continued absolute increase in population with the population anticipated to increase to more than 7 million people by 2025 [22]. The high population density of this city translates to a high number of live vehicles as compared to other Tanzanian regions. It is estimated that between 606,439 to 707,521 cars are plying in Dar es Salaam roads [11]. Consequently, carwash facilities are blossoming in the city mainly along the arterial roads and river banks for easy access of customers and water for washing respectively.

Data collection

A total of twenty-one (21) carwashes were included in the study from nine (9) different areas. From these areas (9) one carwash facility was purposely selected as sampling sites (Figure 1), based on the accessibility to the researcher and willingness of the owners to participate in the study. The sampling facilities were denoted as C from number 1-9, where C was the acronym for Carwash and 1-9 represents the 9 carwash facilities. The sites were marked using a hand-held Geographical Positioning System (GPS) as follows, Kigogo Sambusa [C1 (6^o49'4.67"S 39^o15'30.13"E)], Mbagala Msikitini [C2 (6^o53'1.76" S 39^o16'5.43"E)], Tabata Majichumvi [C3 (6^o49'14.40" S 39^o11'46.00"E)], Ubungo Garage [C4 (6^o48'34.62" S 39^o12'5.63"E)], Temeke Usalama [C5 (6^o51'20.63" S 39^o15'48.55"E)], Sinza Makaburini [C6 (6^o46'48.76" S 39^o13'26.46"E)], Bamaga [C7 (6^o46'22.95" S 39^o14'10.00"E)], Sinza Palestina [C8 (6^o46'56.40" S 39^o13'21.12"E)] and Sinza Mori [C9 (6^o46'40.59" S 39^o13'41.36" E)].

Site Visit

Site visits were intended to observe the existing situation particularly in relation to waste management and types of carwashes. The waste generated in each carwash facility included in the study were collected, sorted, weighed and recorded by the researcher for three days in each carwash consecutively. The expedition during this study took place in September 2018. It was during this visit that the existing wastewater management practices were also assessed.

Interview

Interviews were administered to obtain information on types of cars washed, number of cars washed and waste management practices.

Quantification of Wastewater Generated

In quantifying the amount of wastewater generated, there was a need to quantify the amount of water used. The water used was estimated by means of measuring the flow rate supplied by the wand wash (hoses and/or pressure guns) and recording the time of operation. In the case of hand wash, the number of containers (buckets) used during the process were counted and multiplied by the average volume of a bucket. In both cases the volume of water used per car was multiplied by the total number of cars washed per day in each sampling site. Further it was assumed that 95% of the water used was wastewater generated while the remaining 5% was lost due to evaporation, spillage from the bucket and leaking from pipes. Then the amount of wastewater generated per year was estimated using the following formula;

$$ww_G = A \times 95\% \times 365$$

Where; WW_G - Estimated amount of wastewater generated; A - Amount of water used in each sampling site; 95% - Percent of wastewater generated from water used; 365 - Number of days per year

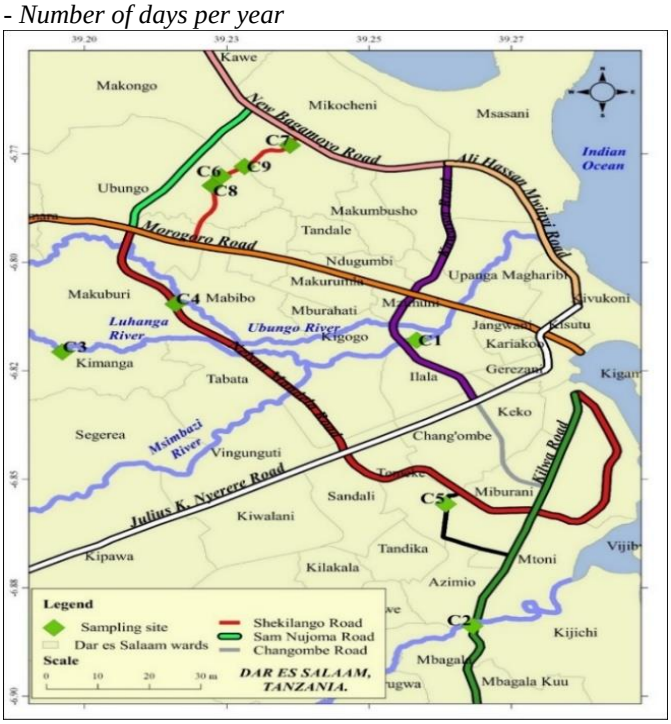

Figure 1.Map of Dar es Salaam showing Sampling site

Quantification of Solid Waste Collected

For the quantification of solid waste, 25 kg sacks were given to the nine carwash facilities. Using the sacks given solid waste was collected three (3) times a week in each carwash and measured using a portable weighing balance (100 kg capacity). Therefore, estimated amount of SW generated in each carwash yearly was established using the following formula;

$$SW_C = SW_T \left(\frac{kg}{d}\right) \times 365 \left(\frac{d}{yr}\right)$$

Where: SW_C - Solid waste collected yearly; SW_T - total solid waste from carwash facilities; 365 - Number of days per year.

Data Analysis

The analyses of data were performed using Microsoft Excel and Instat. Whereas in showing data, descriptive statistics including mean and standard deviation were used. Further, One-way Analysis of Variance (ANOVA) was employed to obtain the significant differences among the selected carwashes at 0.05% level of significance.

Results and Discussion

Carwash Facilities and waste generated in the Study Area

The study evaluated both formal and informal carwash. The formal carwash facilities were those facilities that are legally recognized while informal carwash facilities are referred to as activities which are legal but not legally recorded or registered [20]. The study has categorized carwash facilities into four main types that include in-bay, hybrid, wand wash and hand wash carwashes (Table 1) based on construction and method of washing.

The results in Table 1 show that the study involved 21 carwash facilities from 9 different areas in Kinondoni, Ubungo, Ilala and Temeke District, Dar es Salaam. They also show that 5 (23.8%) facilities are wand wash, 3 (14.3%) hand wash, 3 (14.3%) in bay carwash and 10 (47.6%) hybrid carwash.

The reasons for the observed trend of hybrid carwash being the most preferably facilities followed by wand wash, and the least being in bay carwash and hand wash include being located in planned areas with residences of middle and high income, near the Central Business District (CBD), the largest market (Kariakoo) and the main hospital (Muhimbili) [16].

Table 1. Types of carwash facilities in the study area

Sampling site	Type of carwash	Category	Number of carwash
C1: Kigogo Sambusa	Wand wash	Traditional	1
	Hand wash	Traditional	1
C2: Mbagala Msikitini	Wand wash	Traditional	2
C3: Tabata Majichumvi	Wand wash	Traditional	2
C4: Ubungo Garage	Hand wash	Traditional	1
C5: Temeke Usalama	In-bay	Professional	2
	Hybrid	Professional	1
C6: Sinza Makaburini	Hybrid	Professional	1
C7: Bamaga	In –bay	Professional	1
	Hybrid	Professional	2
C8: Sinza Palestina	Hybrid	Professional	1
C9: Sinza Mori	Hybrid	Professional	5
	Hand wash	Traditional	1
Total			21

During site visits, it was observed that in-bay carwashes are normally located in fuel stations, providing both exterior and interior carwash services, and sometimes car services. Methods of washing involve both pressure pump and hydraulic lifts [9]. In-bay carwash deals with small cars and vans. The amount of water used ranged from 160 to 180 liters per car per day. From the study area the two in-bay carwash facilities (C5 and C7) generated 3,847.5L/day and 5,130L/day wastewater as shown in table 2. The reason for high amount (5,130L/day) of wastewater in C7 was high number of cars washed per day (20 cars for C7 whereas C5 only washed 15 cars per day) while they both used a total average of 90 minutes to wash one car. Solid waste generated in C5 and C7 (in-bay carwash facilities) was 2372.5 kg/yr for both facilities as shown in table 3. As for wastewater management C5 discharge in the municipal sewerage system while C7 discharge in the onsite collection tank (table 4) and later transported to the municipal sewerage system after every two weeks. These acts are unacceptable because apart from oil and hydrocarbons, in-bay carwashes tend to use detergents and waxes which contain harmful chemicals including surfactants and silicone respectively. The later may not be an environmental concern but tend to bond with metals making complex compounds which are harmful to aquatic environment and carcinogenic to human beings [7].

While surfactants are toxic to most aquatic organisms. As for solid waste in both C5 and C7 carwash facilities are collected in special container (dustbins) as shown in table 4 with a capacity of 30kg. Normally they are transported to the municipal dumpsite by municipal trucks once a week.

Table 2.Quantity of wastewater generated in carwash facilities (l/yr).

Sampling site	Amount of wastewater generated daily (liters/day)	Amount of wastewater generated yearly (liters/year)
C1:wand wash	5,130	1,872,450
C2:wand wash	2,565	936,225
C3:wand wash	3,206.25	1,170.281.25
C4:hand wash	304	110,960
C5:In-bay	3,847.5	1,4043,37.5
C6:hybrid	4,750	1,733,750
C7:In-bay	5,130	1,872,450
C8:hybrid	5,130	1,872,450
C9: hand wash	570	208,050
Total (l/yr)	30,632.75	11,180,953.75

Hybrid carwashes are characterized by combination of high pressures wash and a brush or soft cloth. These facilities may provide exterior or both exterior and interior car washing services. The amount of water used is between 120 to 140 liters per car per day. These facilities are characterized with a concrete surface which cause wash wastewater flow into storm drains. The study showed that amount of wastewater generated in these facilities was 4,750L/day for C6 and 5,130L/day for C8 (table 2). The reason for high amount (5,130L/day) of wastewater in C8 was mainly attributed due to number of cars washed per day. These wastewaters can be harmful to humans, plants, and animals if released untreated to surface water bodies. Additionally, if reach the ground, the wastewater contaminates soil and groundwater [4].

Solid waste generated in C6 was 1825 kg/yr while 2190 kg/yr in C8 (table 3). Onsite collection tank was observed to be the main practice for wastewater management in both facilities as shown in table 4. The tanks are mainly emptied once a month. While for solid waste, C6 collect in a 25kg sack while C8 in a 20kg bucket (table4). Both facilities send them to collection points for municipal trucks to collect once a week Wand wash carwashes are traditional facilities, mostly located along river banks and involve washing of heavy trucks. Washing is done by using pressure pumps connected directly from rivers. The amount of water used in these facilities range from 260-270 liters per car per day. This type of carwash erodes river banks leading to river sedimentation. Amount of wastewater generated in C1 was 5,130 L/day, 2,565 L/day for C2 and C3 was 3,206.25 L/day. As for solid waste, the amount in C1 was 5328.5 kg/yr, 4,197.5 kg/yr for C2 and 3,285 kg/yr for C3. C1(5328.5 kg/yr) had the highest amount because the

Table 3. SW collected in carwash facilities (kg/yr).

Sampling site	Mean weight ± SD (kg/yr), n=3						TOTAL
	Food remains	Plastic bags	Plastic bottles	Papers	Rags	Empty containers	
C1: wand wash	1095±2.828	218.5±12.021	2007.5±10.607	182.5±3.536^{a}	1095±11.314	730±19.799	5328.5
C2: wand wash	547.5±5.303^{a}	365±7.071^{a}	182.5±14.142	182.5±6.364^{a}	730±9.899^{a}	547.5±3.536	4197.5
C3: wand wash	182.5±0.0	365±4.243^{a}	1460±4.243^{a}	182.5±2.121^{a}	730±7.071^{a}	365±14.142^{a}	3285
C4: hand wash	0±0.0^{b}	547.5±4.950^{b}	1460±7.071^{a}	0±0^{b}	182.5±3.536^{b}	0±0^{b}	2190
C5: in-bay	730±14.042	182.5±14.849^{c}	730±7.071^{b}	365±7.071	0±0	365±7.071^{a}	2372.5
C6: hybrid	365±15.456^{c}	182.5±3.536^{c}	730±4.243^{b}	182.5±7.778^{a}	182.5±7.778^{b}	182.5±3.536^{c}	1825
C7: in-bay	365±7.071^{c}	365±4.243^{a}	1277.5±10.607	0±0^{b}	365±7.071	0±0^{b}	2372.5
C8: hybrid	547.5±7.004^{a}	547.5±10.607^{b}	730±2.828^{b}	0±0^{b}	182.5±4.950^{b}	182.5±4.945^{c}	2190
C9: hand wash	0±0^{b}	182.5±6.364^{c}	730±7.071^{b}	0±0^{b}	182.5±3.536^{b}	0±0^{b}	1095
TOTAL	3832.5	2956	10950	1095	3650	2372.5	24856

$p<0.05$, mean values with superscript $^{a, b, c}$ in the same column have no significance differences

washing facility washes heavy load trucks that travel in and out of the country. The truck drivers collect all the waste that are generated while buying different items on the way. Wastewater generated in these facilities (C1, C2 and C3) were directly discharged to nearby rivers namely Msimbazi River, Kizinga River and Luhanga River, respectively as shown in table 4. Pollutants from wand wash carwash activities including oil and grease, heavy metals, detergents and surfactants endanger both aquatic lives and downstream residents as they are directly discharged in rivers [17]. Also, many of the commonly used detergents (OMO, FOMA, PUFF) contain phosphates, which promote eutrophication and remove oxygen from the water. Depletion of oxygen has negative consequences on aquatic life [15]. With an exception of C1 both C2 and C3 collect plastic bottles for recycling (table 4). Also, C2 burn plastic bags and papers. This act is unacceptable since plastic bags when burnt emit dioxins and furans which are harmful to human health. Furthermore, due to improper solid waste management, solid wastes find their way into surface water as shown in figure 2 polluting the rivers and threatening aquatic lives [14].

Figure 2. Unattended solid waste floating on a river.

Hand wash carwash uses a bucket, detergents and sponge for washing and are located in streets near drainage systems. This type of facilities normally involves washing of small cars, vans and light trucks. Amount of water used in hand wash carwash range between 30-40 liters per car per day. Hand wash carwash facilities in the study were sampling point C4 and C9. The amount of wastewater generated in C4 was 304 L/day and 570 L/day in C9 (table 2). Whereas amount of solid waste generated in C4 was 2190 kg/yr and C9 was 1095 kg/yr as shown in table 3. The later (C9), had a lower amount (1095 kg/yr) of solid waste collected because the facility provides exterior carwash services only. These carwash facilities tend to discharge these wastewater (304 L/day for C4 and 570 L/day for C9) on the land surfaces by road sides (Nelson Mandela Road and Shekilango Road respectively) as shown in table 4. This endangers the ecosystem when wastewater washes away to the drainage system, streams and to the receiving waters, hence increased environment pollution [6]. Both facilities (C4 and C9) collect solid waste in 25 kg sacks (table 4) which are later transported to the municipal dumpsite by municipal trucks once per week.

In total, amount of wastewater generated daily in these carwash facilities (C1, C2, C3, C4, C5, C6, C7, C8, and C9) was 30,632.75 L/day. While total amount of solid waste generated in the 9 carwash facilities annually was 24,856 kg/yr. Furthermore, results in table 3 indicate that in terms of the amount of solid waste generated, plastic bottles were the most (10950 kg/yr) generated solid waste in the carwash facilities investigated, while papers were least (1095 kg/yr) generated solid waste. The general trend of solid waste generated in the study area was plastic bottles>food remains>rags>plastic bags>empty containers>papers. Also, table 3 shows food remains in both hand wash carwash facilities (C4 ad C9) had no significance difference. This was because in both facilities, the service providers tend to eat in nearby food vendors and leave the waste at the respective areas. It was also revealed that there was significance difference between C6 (hybrid carwash facility) and C8 (hybrid carwash facility). This was attributed by the presences of provision of food services within the facility in C8 as a way to make customers more comfortable while waiting for their vehicles. Moreover, plastic bottles in C4 (hand wash carwash facility) were significantly different from C9 (hand wash carwash facility) as shown in table 3. Though they are both of the same type (hand wash) the former (C4) wash heavy load vehicles while the later (C9) washes light vehicles.

Table 4. Waste management mechanism in the study area

Sampling site	SW Storage Mechanism	Wastewater Management Mechanism
C1: wand wash	• Collects in sacks	• Direct discharge into a river
C2: wand wash	• Collect plastic bottles for recycling, • Burn papers and plastic bags	• Passes through saw dust on the ground before discharged into a river
C3: wand wash	• Collect plastic bottles for recycling • Collects other waste in sacks	• Direct discharge into a river
C4: hand wash	• Collect plastic bottles for recycling • Collects other waste in sacks	• Discharged on the soil
C5: in-bay	• Collects in dustbins	• Discharged in the municipal sewerage system
C6: hybrid	• Collects in sacks	• Collected in tank and transferred by trucks
C7: in-bay	• Collects in dustbins	• Collected in tank and transferred by trucks
C8: hybrid	• Collects in buckets	• Collected in tank and transferred by trucks
C9: hand wash	• Collects in sacks	• Discharged on the soil

The major problems as far as waste generated from carwash facilities are concerned was wastewater with a total amount of 11,180,953.75L/yr while the existing disposal options are scientifically and socially unacceptable. Based on the findings of this research it is envisaged that for the solid waste storage and transfer by truck to the municipal disposal site is the current environmental acceptable option. However, storage facilities need to be improved and upgraded to go hand in hand with upgrades happening in city solid waste management systems and plans. For wastewater disposal the research is in the opinion that all the four methods (discharge in municipal sewerage, onsite collection tanks, discharge in rivers and discharge on soil) are not scientifically acceptable. Therefore, based on the surroundings upgrading the hybrid carwash by introducing hydroponic cultivation of vertiver grass is one of options for handling wastewater. This option can as well allow reuse of the water, and thus minimize the amount of wastewater to be disposed [6].

Conclusions

Contrary to the information obtained from literature and report of studies from other parts of the world where professional carwash facilities are commonly functioning and described as environmentally friendly by use of little amount of water, recycling of water and treatment of wastewater prior to disposal, in this study both professional and traditional carwash facilities investigated share similar properties. They both generate massive amount of wastewater (11,180,953.75L/yr) and solid waste (24,856 kg/yr), do not recycle water, no prior treatment of wastewater disposed, and improper handling of solid waste. Generally, both professional and traditional carwash facilities reported in this study pose relative same challenges to the urban and aquatic environment. The study has however concluded that the better method of solid waste that has to be adopted by all carwash facilities is storage and transfer to collection points or direct to the solid waste trucks. Whereas for wastewater was upgrading the hybrid carwash facility by introducing hydroponic cultivation of vertiver grass. Thus, since carwash facilities are growing at a large pace, monitoring of their establishment is important. This is possible through the enforcement of the National and International legislations and regulations on correct ways of initiating such undertaking that take into considerations of many aspects including disposal of solid and liquid wastes.

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