Eco-sustainable dishwashing practices by Households and Food Catering Units: An exploration

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Abstract— *Washing utensils is an indispensable activity at least in Indian scenario. When utensils are washed many resources are required such as water, electricity, cleaning agents, time and human efforts. Water which is generally used for washing utensils is the treated or portable water. Lot of mal practices by those involved in washing utensilstherefore there is a need to understand need for water conservation.*

Keywords— Resources used, Dishwashing practices, Reuse and Recycle of waste water.

I. INTRODUCTION

Dish washing is the process of cleaning cooking utensils, dishes, cutlery and other items. This is either achieved by hand in a sink or using a device referred to as a dishwasher and may take place in a kitchen, utility room, scullery or elsewhere. There are cultural divisions over rinsing and drying after washing.

Washing utensils is an indispensable activity at least in Indian scenario. When utensils are washed many resources are required such as water, electricity, cleaning agents, time and human efforts. Water which is generally used for washing utensils is the treated or portable water.

The present study has attempted to study the dishwashing practices with respect to the use of resources for cleaning dishes in the households and food catering units. . The study proses if wastewater generated from manual or machine wash can be reused by recycling waste water for domestic work which can help to reduce the load on treated water.

II. REVIEW OF LITERATURE

The manual dishwashing relies largely on physical scrubbing to remove soiling, while the mechanical dishwasher cleans by spraying hot water, typically between 55 and 75 °C (130 and 170 °F) at the dishes, with lower temperatures used for delicate items (weburbanist, 2012). To kill most of the bacteria on a dirty dish, water must reach a scalding 140° Fahrenheit. That temperature is easily reached in a dishwasher, but in a sink, it is nearly impossible. Hot-water heaters are typically set at 120 degrees to prevent burns, and most people can't stand to keep their hands in a stream of water that too hot for more than a few minutes (http://www.apartmenttherapy.com/do-you-really-need-a-dishwasherreal-simple-173109).

According to the study, London alone could save as much as 16 billion litres (4.2 billion gallons) of fresh water a year, if every household used a dishwasher instead of washing by hand, and as the dishwasher uses less water and time, it would also use less energy to heat it up. The study finding revealed that on an average 10.5 litres(2.77 gallons) of water is used per person, each day, when washing the normal amount of dishes by hand, whereas best dishwashers used only 2.27 litres (.59 gallons) of water to wash the same amount of dishes (per person, per day) and would require less energy to heat up the smaller amount of water. A full cycle in the dishwasher will consume about 15 litres (4 gallons) on an average. The most efficient water saving dishwashers uses 11.3 litres (3 gallons) of water per cycle (Jamila Le, 2009).

The minimum Federal energy standard for dishwashers established by the U.S. DOE 2003 rule making specifies an Energy Factor, or EF of at least 0.46 cycles/kWh for standard-size dishwashers for the “normal” cycle. Thus, a minimally compliant dishwasher would use 2.17 kWh per load of dishes. For estimating the labeled annual energy use of dishwashers, it is assumed that the typical household has 215 dishwasher loads each year so that the minimum compliant dishwasher would use 467 kWh/year, not including standby losses for control electronics which are often about 2 watts (~17 kWh/year.). However, modern dishwashers vary substantially in their energy use. Energy Star dishwashers have an EF of 0.65 or higher so that they would use 30% less energy than a standard model. Currently, the most efficient dishwashers of a standard size sold are Bosch Integra units (such as the SHX98M09) with an EF of 1.14 indicating they use about 0.88 kWh/cycle or 190 kWh/year (Hoak, Parker, Hermelik, 2008).

One cycle in a typical dishwasher costs the same in energy and water as heating between four to six washing-up bowls of water in the kitchen sink, or running the hot tap continuously for six to nine minutes (depending on

whether the household has a metered or unmetered water supply). The lower estimate is for a household that pays for water by meter, while the higher estimate is for a household that pays for water by rateable amount. If one washed up by hand for more than nine minutes, or uses more than six washing-up bowls for dishes, then one is likely to save more by fully loading the dishwasher up once (Christie, 2014).

History of dishwashers

The first patent granted for a device that washed dishes was back in 1850, invented by a man named Joel Houghton. He created a small, crank-operated machine that was built from wood. When cranked, water would make its way through the wood plumbing and spray over the dishes. This idea didn't take hold until a wealthy woman named Josephine Cochrane fine-tuned Houghton's invention in 1887 and entered it in the World's Fair. While she didn't wash dishes herself, Cochrane claimed that her servants often chipped dishes and used the dishwasher as a way to simplify the dishwashing process (Curtis, 2014).

In England, William Howard Livens invented a little dishwasher ideal for domestic use in 1924. It had been the initial modern dishwasher, and included most of the design components that function in the type of today: it included an entry way for loading, a wire rack to carry the filthy crockery and a rotating sprayer. Drying elements were actually added to his design in 1940. It was the first machine suitable for domestic use, and it came at a time when permanent plumbing and running water inside the home was becoming increasingly common. Despite this, Liven's design did not become a commercial achievement, and dishwashers were only successfully sold as domestic utilities in the post war-boom of the 1950s, albeit only to the wealthy. Dishwashers had been sold as standalone or portable devices initially, but with the advancement of the wall-to-wall counter top and standardized height cabinets, dishwashers started to end up being marketed with standardized sizes and shapes, integrated underneath the kitchen countertop as a modular unit with other kitchen appliances (Hilpern, 2010).

By the 1970s dishwashers had become commonplace in domestic residences in North western America and Europe. By 2012, over 75 per cent of homes in the Germany and US had dishwashers Curtis (2014).

Detergents used for washing utensils

Dishwashing requires detergents with very special characteristics because of the conditions under which the detergent must work. One of its essential characteristics is that it must produce little or no suds or foam because too much foam can inhibit the washing action. Other important functions that a dishwashing detergent should perform are the following:

- Make water wetter (reduce surface tension) to penetrate and loosen soil.
- Tie up water hardness minerals to permit the detergent to do its cleaning job.
- Emulsify greasy or oily soil.
- Suppress foam caused by protein soils such as egg and milk.
- Help water to sheet off surfaces of dishes, thus minimizing water spots.
- Protect china patterns and metals from the corrosive effects of heat and water alone.

Ingredients of the utensils cleaning agents

To accomplish these functions, the following ingredients may be included depending on the formulation and product

Surfactant (non-ionic)- Lowers the surface tension of water so that it will more quickly wet out the surfaces and the soils. Lowering the surface tension makes the water sheet off dishes and not dry in spots. The surfactant also helps remove and emulsify fatty soils like butter and cooking fat. Non-ionic surfactants are used because they have the lowest sudsing characteristics.

Builder (complex phosphates)- Combines with water hardness minerals (primarily calcium and magnesium) and holds them in solution so that the minerals cannot combine with food soils and so that neither the minerals themselves nor the mineral/food soil combination will leave insoluble spots or film on dishes. A builder helps maintain a desirable level of alkalinity, necessary for good soil removal.

Corrosion inhibitor (sodium silicate) - helps protect machine parts, prevent the removal of china patterns and the corrosion of metals such as aluminium.

Chlorine compound- Aids in sanitizing, helps make protein soils like egg and milk soluble, aids in removing such stains as coffee or tea and lessens spotting of glassware.

Special additives (sodium aluminate, boric oxide, aluminium phosphate, etc.)- May be used to inhibit over glaze and pattern removal from fine china.

Additional alkalis (sodium carbonate, trisodium phosphate) -May be used to aid in handling greasy food soils.

Perfume- Covers the chemical odour of the base product and stale food odors which might otherwise emanate from the dishwasher.

III. RATIONALE OF THE STUDY

Wherever there are human beings there is food followed by dishes to be washed. Every households and food catering unit engages a lot of time for washing dishes. Moreover, these are washed manually (rarely using dishwashers) by using treated water and yet most of the

times dishes are not cleaned properly. In other words, they are not sanitized and pose a threat for infection and human health.

The present research attempts to study the dishwashing practices with respect to the use of resources i.e., water, electricity, cleaning agents, etc. for cleaning dishes in the households and the food catering units. Some studies have reported that 15 gallons (56.7 litres) of water is used for washing dishes (each time) and all of it goes to the drain. Findings of the study focus on the aspects whether resources used for dishwashing, particularly water and electricity consumed (are used either for water pumping or for operation of dishwashers.

IV. OBJECTIVES

- To study the existing dishwashing practices and compare the effectiveness of manual washing of utensils vis-à-vis, using a dishwasher in terms of :
  a) Cleanliness/ hygienic wash
  b) Resource efficiency with respect to use of water, electricity and cleaning agents.
- To propose a sustainable model for eco-efficient dishwashing practices.

V. METHODOLOGY

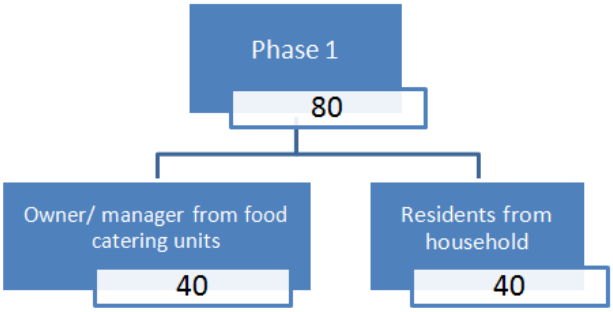
Phases of the study

The following study was be carried out in 2 phases as represented below:

Phase 1: Survey of practices concerned washing of utensils by the stakeholders.

Phase 2: Assessment of the composition of waste water from sink and dishwasher and hygiene level of washed utensils

Sample was selected from NCT of Delhi.



Sample

A total of 80 respondents were selected from 40 households (HHs) and 40 food catering units (FCUs). HHs either lived in independent houses or in apartments. FCUs included small restaurants.

Phase 1: Survey of practices concerned washing of utensils by the stakeholders.

In this phase, a survey was conducted in 80 stakeholders i.e. 40 households and 40 food catering units. The survey focused on practices followed by them for washing utensils and reuse of waste water generated from the kitchen.

Informal discussionswere conducted for getting in-depth knowledge of the washing practices and observation sheet was made for the same.

5.3.2 Phase 2: Assessment of the composition of waste water from sink and dishwasher and hygiene level of washed utensils.

Step I: *Collection of waste water samples. All plastic bottles were rinsed with lukewarm water before collecting water samples.*

Three households and food catering units were identified who were washing utensils manually and by machine. They were instructed to wash the dirty utensils by both the methods and store the washed utensils in a sterilized bag immediately after washing. The dirty water after washing of utensils were collected in a sterilized bottles which were stored in refrigerator 24 hours before conducting the experiment.

Step II: Critical parameters selected for effectiveness of dishwashing activity.

Experiment was conducted to study the performance of dishwashing activities following parameters:

- Resources used
  Quantum of Water consumption: Water bucket was taken and marks were made after every 2L i.e. 2L, 4L, 6L etc. the waste water was collected in the bucket while washing of utensils and was compared with the mark to know the exact quantity of water consumed.
  Quantum of Electricity consumption: Each respondent was asked about the storage tank installed in their house and how much time did it take for filling. Then using unitary method electricity consumption was calculated. For example, a house had 2000L of water tank and fills up in 10 minutes and consumes 160kw. So, 30L of water will consume 2.5kw of electricity.
  Cleaning materials used: Interview of the respondents were done to know which cleaning agent they used for washing dishes and for how long did it last. For example, if a HH used 500ml of liquid detergent and it last for 15days. They wash utensils 3 times a day. So the total consumption of liquid per day will be 500/75= 6.6ml of detergent.
- Hygiene
  Cleanliness of utensils- Hygiene of utensils was examined by visual examination and by conducting microbial plate count test in the laboratory.

- Waste water
  Composition of waste water- physical and chemical composition of waste water was examined by laboratory testing.
- Heart rate
  Heart rate (as an indicator of human effort involved) was measured just before and after washing the utensils by both the sample groups to calculate the difference between the two.
- Temporal factor
  Time duration of washing dishes- Interview was done to know the time required by the respondents from both the sample groups i.e. FCUs and HHs for washing utensils.

Step III: Conducting tests to evaluate waste water samples

Suitable tests were conducted to study the parameters of effectiveness of dishwashing. The parameters covered were pH, Hardness of waste water, calcium (Ca), chloride (Cl), phosphorus (P),suphur (S), TD,nitrogen (N), biological oxygen demand (BOD) and carbon oxygen demand (COD).

VI. RESULTS AND DISCUSSION

6.1 Baseline information of respondents

Majority of the respondents were below 45 years of age and were graduates in FCUs whereas in HHs, some of them were educated upto intermediate level (22.5%) and some upto post graduate level (20%). All the respondents were male in FCUs whereas all the respondents from HHs were females. In HHs, most of the respondents were either housewives or were in Government or private service. Very few were involved in business. In was found that in HHs nuclear families were predominant over extended or joint families.

6.2 Practices with regard to washing utensils

6.2.2Number of utensils used for serving food by two selected groups of users

It was found that FCUs used more number of utensils as compared to HHs because of more footfalls. FCUs washed more than 80 utensils were wash whereas HHs washed upto 40 utensils

6.2.3 Time spent in washing utensils

Majority of the respondents from both the sample groups i.e. FCUs and HHs spent 30 to 60 minutes in washing dishes per wash. The reasons for spending 30-60 minutes for washing utensils at a time by FCUs was because they offered shift service and for HHs was that the utensils used at a time were very few.

6.2.4Number of Times in a day dishes were washed

All FCUs and more than half of the HHs washed utensils more than 3 times a day. Very few HHs washed utensils less than 3 times a day. The reason for majority of respondents washing utensils more than 3 times a day was that even in HHs open kitchen concept was prevalent due to which they preferred to keep their kitchens clean all the time. Dishes were washed more than 3 times a day in FCUs.

6.2.5 Washing agents used for washing dishes

Majority of the respondents from both the sample groups preferred liquid soap over cake and powder. The reason for this was because liquid soap dilutes well in water with proper concentration and lasts longs.

6.2.6Practice of washing dished using a dishwasher

It was found that very few respondents from both the sample groups used dishwasher for washing machine. They used 240 volts machine and used liquid soap for washing utensils. HHs run a dishwasher for an hour and used it monthly or occasionally when there was a party or get together whereas FCUs for 2 hours daily or weekly. Majority of them were satisfied with the performance of dishwasher in terms of stains, feel on touch, brightness and smell from washed utensils.

6.3 Material of utensils used by respondents

6.3.1 Meals and occasions on which different utensils were used

It was found that the use of disposables in FCUs was practiced more for take away orders whereas durable dishes like metal and glass were used for those who preferred to dine at the FCUs. On the other hand, HHs when used disposables, were the occasions when they ordered food from outside or when they wanted to avoid washing of dishes. Respondents preferred durable and reusable utensils as compared to disposables because they were more hygienic, attractive and have low maintenance cost.

6.3.2 Frequency of use of disposables

All the FCUs, which used disposables for packing of food, used them daily whereas majority of HHs used disposables either monthly or occasionally.

6.3.3 Numbers of disposables used

Different types of disposables such as cups, tumblers, plates, bowls, spoons, forks and food packaging containers were used by the HHs and were used in very few in number i.e. upto 50. Whereas FCUs preferred food packaging containers and were used in large quantities i.e. upto 100 daily.

6.3.4 Criteria to determine cleanliness of utensils

It was found that majority of the respondents were satisfied with the washed utensils in terms of shine, feel on touch, brightness, smell and colour. When discussed, respondents practiced pre rinse of utensils immediately after use which prevented utensils from getting any stains which helped to retain its colour.

6.4 Reuse of waste water from kitchen

It was found that none of the FCUs reused waste water generated from the kitchen after washing of dishes. On the other hand very few HHs i.e. only 10% reused grey water for domestic use. Majority of them used grey water for landscaping followed by washing vehicles and sweeping.

6.5 Ergonomic factors of washing utensils

6.5.1 Feel of physical discomfort

It was found that majority of HHs felt physical discomfort and pain in neck, lower back and arms whereas very few FCUs felt as such discomfort. The reason for not experiencing physical discomfort by the FCUs was that they generally have shift work and at every shift minimum two workers who were involved in washing the utensils whereas in HHs mainly maids or mother or daughter-in-law of the family washes dirty dishes.

6.5.2 Experience of fatigue

Majority of HHs felt the feeling of fatigue after washing dishes which is not a case in FCUs. FCUs had male staffs and they were only appointed for washing dishes who work in shifts therefore, their work was not continuous but shared so were able to relax intermittently and prevent excessive fatigue maintaining one specific body posture. In HHs the same women were expected to wash the dishes along with other domestic work probably due to too many tasks, they felt fatigued.

6.6 Resources used while washing dishes: manual vs. using a dishwasher

- Quantum of water used was more in manual wash.
- Quantum of electricity consumed was more in machine wash.
- Quantum of time consumed was more in machine wash.
- Heart rate was found to be more while manual washing.

6.7 Composition of wastewater

Experimental examination of composition of waste water from kitchen that:

- pH was in the permissible level in both the samples.
- Wastewater analysis results clearly point out that in the collected samples, hardness, chloride, sulphates and ammonia were found to be much more than the permissible levels. Hardness due to the presence of soap. The components had to be removed/ minimized or brought within the permissible levels before waste water could be reused.

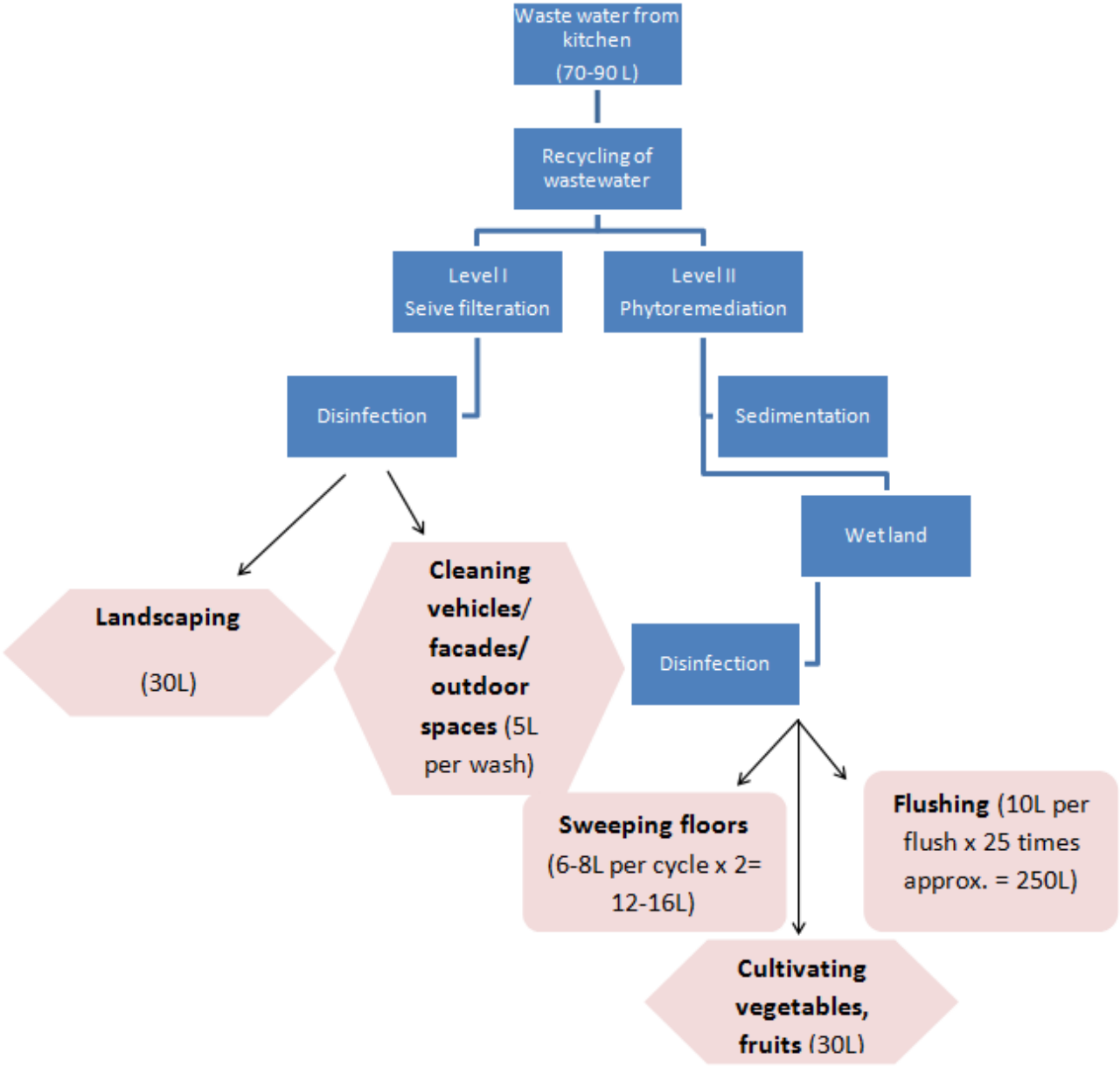
6.8 Microbial plate count on washed utensils

- Utensils washed in a machine were more hygienic as compared to manual wash in both the sample groups as number of colonies in manual wash ranged from 10-2400 whereas in machine wash were in the range of 3-20.

6.9 Major outcomes of the research

Finding of the research clearly indicates that

- Manual washing of utensils consumed more resources as compared to machine washing of utensils viz. a. viz., water 11.5 to 15litres per cycle of utensil wash as compared to 22.5 to 30litres per manual wash; electricity 2kh/hr per cycle of utensil wash as compared to 2kw/hour per manual wash; cleaning agents 5.55 ml per cycle of utensil wash as compared to 6.66ml per manual wash. Besides these, human effort for this activity is not much as it is a sedentary activity as observed in the experiment by increase in heart rate.
- Dishwasher is more hygienic than manual dishwashing as dishwashers give more bacteria free utensils as compared to hand washed utensils.
- For recycling of waste water coarse sieve method or phytoremediation technique can be used by which makes waste water can be recycled and made clean for reuse of various applications like landscaping, gardening, washing clothes, cleaning vehicles and mopping.
- **Eco-sustainable model for recycling of wastewater** had been proposed. It could be done at two levels.
    - First the **sieve method or coarse filtration** involving minimal expenditure (Rs. 1000/- to Rs 2000/-) wherein the recycled water can be used for landscaping and for cleaning outdoor façade etc.
    - Second the **phytoremediation method** which can remove most of the impurities so that the water can be used for various domestic tasks such as landscaping (cultivating vegetables, fruits, flower at personal kitchen garden), sweeping of floors, flushing of toilets, etc. phytoremediation method may be somewhat expensive and also require some land space for execution. It requires additional expenditure for construction of tanks (approximately 30,000/- to 50,000/- for individual household as bigger tanks will cost much more) where sedimentation, filtration and disinfection could take place.



It is recommended from the study findings that-

- Users should make use of wastewater generated from washing utensils as impurities in this water can be removed easily employing simple methods.
- Adopt methods for washing utensils that consume relatively less water, either three sink method or machine wash of utensils as water consumption is half as compared to manual wash.

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