UTILIZATION OF DOMESTIC WASTE WATER FOR CONSERVATION OF POTABLE WATER THROUGH TREATMENT, RECYCLING & MANAGEMENT OF GREY WATER

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Abstract

Grey water is domestic waste water, produced at our house round the clock, excluding sewage and Toilet water. It is generated through our daily household activities like: Bathing, Hand washing, Ablution, Cloth washing, Floor cleaning, Vehicle cleaning cum washing, Utensil cleaning and Kitchen waste water. It accounts for 65 to 70% of Municipal water supply towards domestic purpose; while the remaining portion is consumed among cooking, food preparation and drinking purpose of potable nature.

The grey water management has been successfully executed at local level for conservation of substantial amount of potable water. It is carried out through separate pipe line system in between generation cum collection of grey water and toilet waste [Black water] without their intermixing, which normally has not been practiced in our existing water supply-distribution of waste water pipe line outlay.

The methodology for the adequate treatment, recycling and reuses aspects of grey water with required qualitative and quantitative norms has been reviewed-globally to nationally, in the context of one of the major eight components of Jal Jeevan Mission: Har Ghar Jal. The proper implementation of grey water management at local level [Residential colony, Mohall, Hata, Community] may act as boon for battle- ship against water scarcity. It has scope in improving water availability for Industrial purpose, Irrigation purpose, Recreational purpose, Cultivation of fruit crop, Greenery maintenance- subject to change our mentality for its acceptance and reuses under prospective sustainable living standard.

Introduction

The Ministry of Jal Shakti, Government of India [formed in the month of May, 2019] has launched Jal Jeevan Mission [JJM]: Har Ghar Jal on 21 December 2019, with the cost of Rs 3.50 Lakh crores. It has aim to enable every rural household to have Functional Household Tap Connection [FHTC] for providing potable water by 2024. JJM has eight major components and one of them is "Grey water management-treatment & Reuse". The grey water management is the key element of domestic water supply [3]. The domestic water supply is Municipal water, provided by Government to individual end user [household] with pressure of potable nature through pipe line system. The source of water may be either central well/bore-well [Ground water] or treated surface water through pond, river /overhead tank. The grey water is generated by every household as post use of domestic waste water.

The potable water is suitable for drinking and cooking food purpose with standard qualitative and quantitative norms as per IS: 10500 [2012] and erstwhile National Rural Drinking water Program [2012] /latest National Water Policy [2012] respectively, has been considered in JJM. The details of standard for quantitative

norm as per erstwhile National Rural Drinking Program [2012] and as qualitative per IS: 10500 [2012] are summarized respectively as Table1 & 2. The availability of potable water with optimum quality and quantity has to be ensured by elected government for bona-fide tax payer/ citizen as per constitutional right in Democracy for voter [mass public].

S N	Nature of domestic purpose	Quantity in liter per capita per day [lcpd]
1	Drinking	03
2	Cooking Food	05
3	Bathing	15
4	Washing of all kinds	07
5	Ablution	10
6	TOTAL	40

Table 1: Quantity norm for potable water requirement as per erstwhile National Rural Drinking water Program [2012]

JJM has enhanced the potable water quantity from 40 to 55 lcpd towards long term basis that is for next 15 years with projected population of 40 % growth on the basis of 2011 census, with tap connection. The enhanced quantity of water has been considered for planning implementation of water security and improvement of living standard.

S N	Parameter with [unit]	Accepted limit	Cause of Rejection limit
1	Turbidity [NTU]	1	10
2	Color [on Platinum-cobalt scale]	5	25
3	Taste & Odor	Un-objectionable	Un-objectionable
4	p H	7.0-8.5	<6.5 - >9.2
5	Total Dissolved Solids [mg/l]	500	2000
6	Total Hardness-Ca CO3 [mg/l]	200	600
7	Chloride-Cl [mg/l]	200	1000
8	Sulfate-SO4 [mg/l]	200	400
9	Fluoride –F [mg/l]	1.0	1.5
10	Nitrate-NO3[mg/l]	45	45
11	Calcium-Ca [mg/l]	75	200
12	Magnesium-Mg [mg/l]	30	150
13	Iron-Fe [mg/l]	0.1	1.0
14	Magnese-Mn [mg/l]	30	150
15	Copper-Cu [mg/l]	0.05	0.5
16	Arsenic [mg/l]	0.05	0.05
17	Alkanity [mg/l]	200	600

Table 2: BIS Quality norms for potable water as per IS; 10500 [2012]

Total Dissolved Solids [TDS] has close co-relation with salinity.

Evolved Methodology

The evolved methodology is based upon conventional approach as Relevant Literature Review with scrutiny of available BIS code provision for drinking water and Government documents on JJM, Standing Committee on Water Resources and Hindu Newspaper [Chennai edition].

The objectives of study are as follows:

- Concept and component of grey water with allied aspects.
- Quantitative and qualitative aspects of grey water.
- Pre-requisites for treatment and status of technology for grey water reuse.

Relevant Literature Review

The term grey water is defined as, "All un-treated waste water from household, which have not been contaminated by toilet water [5]." The amount of generated grey water from individual household depends upon living standard of person and practices adapted during consumption of water in daily life. It may vary from 10-15 liter per capita per day by ordinary family to the tune of ten times higher by rich people. It is governed by Bath room waste water [25%], Hand wash basin [15%], Cloth/Utensil cleaning cum washing [20%], miscellaneous [10%]-which includes Floor washing, Vehicle washing & Gardening and remaining kitchen sink.

Grey water has been used as supplement of domestic water for utilization of all purpose, except drinking, cooking- food and reduces the load on municipal water supply of potable nature, after suitable treatment & recycling at several countries like: UK, USA, Israel, Jordan, Germany and Australia [9]. There are 8 million operational grey water systems at Arizona, New Mexico, Texas & California provinces of U S A with 22 millions end users, since the past 60 years. The Bio-sand filter with cost of # 60 dollar as simple grey water treatment system, developed by Calgary University in Canada during 1990 are successfully working at Nepal and Bangladesh [12]. The further low cost locally developed Bio-filter of 50-60 gallon capacity grey water treatment system is smoothly working with cost of Taka 1000- 1300 in Bangladesh [10].

Grey water has been used in India at Nagpur and Chennai. The installed separate pipe system for grey water through Bath room and Wash sink at Residential flats of 8 household in colony is smoothly working at hinge road Octroi barrier [Naka] of Nagpur since 2015 [8]. The Chennai Metro Water Supply & Sewage Board has 1200 MLD domestic water supply, with generation of 600 MLD [Million Liter per Day, as grey water [1]. The treated grey water is supplied to industry and certain Residential area for toilet flushing to reduce load on fresh water supply under strict regulation [11].The grey water reuse promotes the awareness and sensitivity to natural hydrological cycle at household level including Rainwater Harvesting towards saving potable water resources.

The grey water has potential application, after treatment in drip irrigation for fruit cultivation, spraying, maintenance of greenery, reducing load on municipal water supply & sewage system and development cum preservation of wet-land. The major application of treated grey water has been summarized in Table 3.

S N	Nature of Grey water Application	Purpose
1	Residential & Commercial zone	Toilet Flushing
2	School/ College/ Community Building	Floor Washing
3	Mall/ Multiplex /Car Parking	Vehicle Washing
4	Construction Industry	Concrete Preparation & Curing
5	Hospital/Nursing home	Gardening, lawn maintenance
6	Urgent Social needs	Fire fighting, Sanitization

Table 3: Grey water application for societal mission

Grey water management is the reuse of domestic waste water [except toilet water] after its suitable treatment & recycling through different pipe system without the intermixing with any other kind of water, along-with following objectives:

- To avoid damage to building and its surrounding from inundation, water-logging during rainy season.
- To avoid creation of bad smell and odor of stagnant waste water on ground surface as breeding sites for mosquitoes.
- To prevent entrophication of stagnant waste water.
- To prevent contamination of local sub-surface aquifer system.
- To use for landscaping, plantation and groundwater conservation.
- To prevent public health risk.
- To ensure that grey water installation system does not harm the environment or cause nuisance.
- To maintain the regulation standard in accordance with statutory norm of competitive body.

Result & Discussion

The supply-demand chain of standard quality and quantity of municipal water to public has been under stressed condition since 1990 in India. The municipal water supply for domestic purpose of potable nature was initiated during British era by Government for town and cities. It was running smoothly with good management during British period and continued in independent India. The water availability per capita per year in cubic meter was 5177 in 1951. The global standard for water crisis is 1700, as water availability per capita per year in cubic meter, which was crossed during 2000 in India. The decreasing trend has been continued with 1368 in 2019 with expected value of 1293 in 2025 as well as 1140 in 2050. The landmark of 1140 has been already crossed in Gujarat. The Government of India has expressed political will/desire to overcome on water crisis through JJM in 2019 with partial fulfilling the following objectives:

✓ <u>Concept and component of grey water with allied aspects</u>

Conceptually, all the domestic waste water generated through our daily routine activities at house [except Toilet water] is grey water. It includes kitchen sink waste water [Green water].It may also include waste water from mass public places, rejected through hand-wash basin/sink [without contamination of Toilet water] like: Railway platform, Bus stand, Restaurant/Hotel and worship places.

The major components of grey water has the remains as tint of detergent, soap, shampoo, toothpaste, shaving cream, human hair and sanitizer belonging to anthropogenic activity. It possesses high pH, high alkalinity.

The separate pipe system is needed for collection of generated grey water at our household and its further treatment & recycling for reuse by end-user. The installation of pipe system should be straight [no necks /depressions] with gradient of at least 0.5 %, in order to prevent from clogging through grease & oily substances, normally present in grey water.

The grey water environment is favorable for bacterial growth. It needs to be treated before reuse by end-user. Further- more, untreated grey water, if collected and remains idle for 24 hours, it turns into anaerobic condition [its oxygen is depleted] and thus creates foul odors.

The technical component of grey water management system is illustrated as Fig.1.

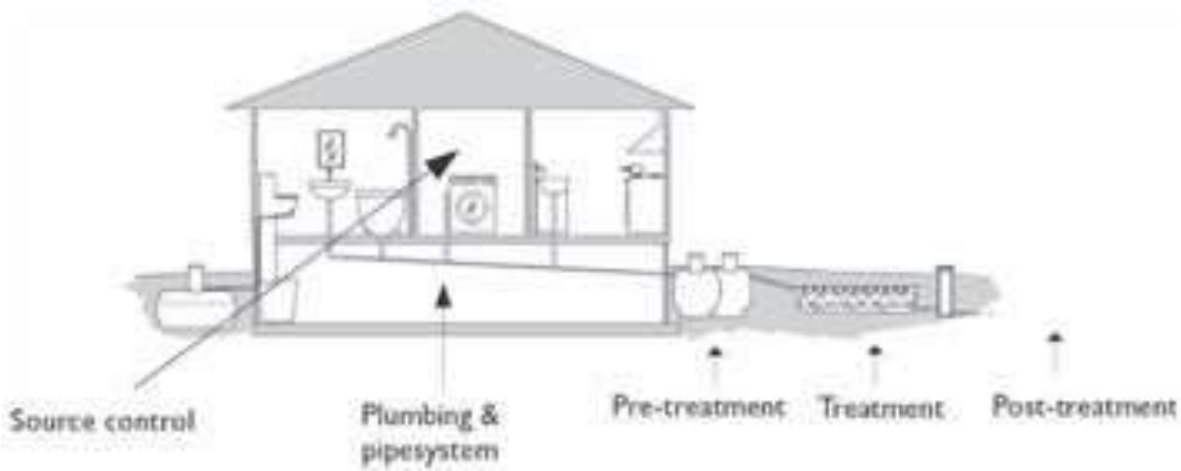

Fig.1 Technical component of grey water management system

The allied aspects of grey water include educating public with its importance by mass media, availability of consultants in grey water management and information in about successfulness. The mass media has responsibility to convenience the public, as done in neighboring countries like: Nepal, Bangladesh with highlighting cost factor, health issue and saving of potable water. Two consultants are available in this field located at Pune and Dubai, who takes care job on turnkey basis for treatment and recycling of grey water.

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✓ Quantitative and qualitative aspects of grey water

The source of grey water at our household is municipal water. The ideal quantitative distribution of municipal water to our household has been illustrated as Fig.2.

Fig. 2 Quantitative distribution of Municipal water [including grey water] at household

The qualitative aspect of grey water has been explained with several parameters like: Physical, Chemical, Hydro-chemical, Micro-biological and Nutrient vise. The details of these parameters are

discussed, in order to overall visualization of quality aspect of grey water, since it has direct influence on public health with governing the potable nature of water for domestic purpose.

The physical parameters of grey water from Bathing, Washing cloth /utensil and Kitchen sink like: Color, Total Suspended Solids, Total Dissolved Solid, Turbidity and Temperature have been studied in 2001[2] and summarized as Table 4.

S N	Name of Physical parameter	Unit	Bathing	Washing	Kitchen Sink
1	Color	Plat/Co Scale	60-100	50-57	
2	Total Suspended Solid	mg/l	48-129	79-280	139-1300
3	Total Dissolved Solid	mg/l	126-175		
4	Turbidity	NTU	20-36	14-296	
5	Temperature	Degree Centigrade	18-38	28-32	

Table 4: Physical parameters of grey water

The chemical parameters of grey water depend upon low content of organic substances in association with nitrogen, oxygen, sodium and phosphate related substances. Eight chemical parameters have been studied in 2007[9] and summarized as Table 5.

The Hydro-chemical parameters of grey water depend upon the type and quality of detergents, soap, shampoo, toothpaste, shaving cream and related solvents. Ten hydro-chemical parameters have been studied in 2001[2] and summarized as Table 6.

The Micro-biological parameters of grey water govern the water borne diseases, based upon bacterial contamination. Four such parameters have been studied in 2001[2] and summarized as Table 7.

S N	Name of Chemical parameter	Unit	Value in range
1	Suspended solid	mg/l	45-330
2	BOD 5	mg/l	90-290
3	Nitrate	mg/l	0.1-0.8
4	Ammonia	mg/l	0.1-25.4
5	Total Phosphate	mg/l	0.6-25.4
6	Sulfate	mg/l	7.9-110
7	pH		6.6-8.7
8	Electrical Conductivity	M s/cm	325-1140

Table 5: Chemical parameters of grey water

S N	Name of Physical Parameter	Unit	Bathing	Washing	Kitchen Sink
1	pH		5-8.1	9.3-10.0	6.3-7.4
2	E C	Ms/cm	82-2000	190-1400	20-340
3	Alkalinity	mg/l	24-136	83-200	
4	Hardness- as CaCO3	mg/l	18-52		
5	BOD5	mg/l	76-200	48-380	
6	COD	mg/l	280-800	375	26-1600
7	DO	mg/l	0.4-4.6		22-588
8	Sulfate	mg/l	12-40		
9	Chloride-as Cl	mg/l	3-18	9-88	
10	Oil & Grease	mg/l	37-78	8-35	

Table 6: Hydro-chemical parameters of grey water

S N	Name of Micro-biological Parameter	Unit	Bathing	Washing	Kitchen Sink
1	Colifage	PFU/ml x10[6]	388	102	< 3
2	Faecal Coliform	Per 100 ml x10[6]	108	9-16	
3	Total Coliform	Per 100 ml x10[5]	20-28	56-84	0.2-376
4	Bacterialpll	Cfn/100ml x10[8]	6.4-300		

Table 7: Micro-biological parameters of grey water

The Nutrient parameters of grey water govern the fertility of soil for cultivation purpose. The grey water has low Nitrogen/Phosphate ratio as < 2, typically favors the fertility of soil with promoting irrigation condition. Five such parameters have been studied in 2001[2] and summarized as Table 8.

S N	Name of Nutrient Parameter	Unit	Bathing	Washing	Kitchen Sink
1	Ammonia [NH3-N]	mg/l	0.1-25	0.1-3.7	0.2-23
2	Nitrate & Nitrite[N]	mg/l	0.5-0.2	0.10-0.30	
3	Phosphorous [PO4]	mg/l	4-35	4-15	0.4-4.7
4	Total Nitrogen	mg/l	0.6-7.3	6-21	13-60
5	Total Phosphorous	mg/l	0.1-22	0.62-5.7	3.1-10

Table 8: Nutrient parameters of grey water

✓ Pre-requisites for treatment and status of technology for grey water reuse

There are three main pre-requisites at planning stage for installation of typical grey water treatment system and as follows:

[a] Separate pipeline / plumbing system for generation and collection of grey water at individual household. It must not allow mixing with Black water.

[b] Grey water installation system should be site specific and able to perfect treat cum recycle within 24 hours of it's generation before end-use.

[c] Responsibility to an authorized authority for operation and maintenance of system round the clock under strict regulation norms and periodical review with end users [preferably educated ladies].

The construction, installation, operation of grey water treatment cum recycling system must consider the following aspects beforehand during planning stage [2]:

[A] Cost and with responsibility of its affordability.

[B] Physical cum socio-economic environment of the locality.

[C] Availability of local manpower and material for its maintenance round the clock.

[D] Characteristics of generated grey water.

[E] Purpose of grey water application by end users.

The grey water treatment methodology has three approaches namely: Primary, Secondary & Tertiary. The primary treatment deals with removal of undesired substances of either floating character or settling down behavior. It removes about 30 % carbonaceous materials, present in grey water. It is carried out through either sedimentation pond or super-imposing four earthen pots containing gravel, sand, charcoal and lower most for clean water, as typical conventional method. The secondary treatment deals with removal of settle-able solid substances. It takes care about 90 % for COD, DO. It is carried out through aerobic pond, Trickling filter with adequate disinfection. The tertiary treatment deals with removal of BOD, Organic substances and remaining impurities of primary, secondary treatment [12]. It is carried through advanced technology as constructed wetland, as illustrated in Fig. 3[2].

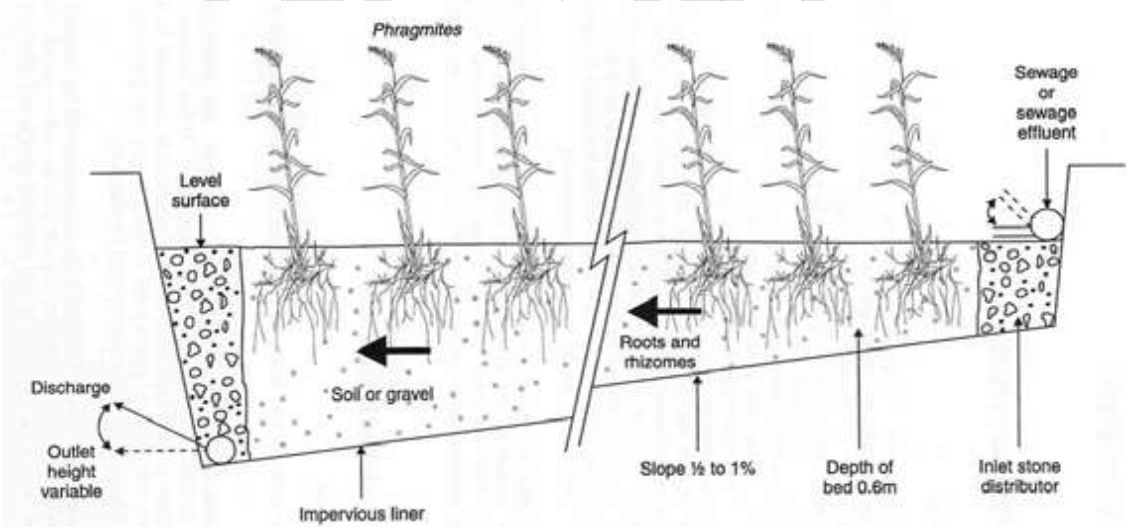

Fig.3 Schematic design of Wetland

Grey water treatment system may be of low cost, involving primary treatment only. It may be of higher cost with involving secondary and tertiary treatments. The choice of grey water treatment system depends upon owner's willingness, installation of recycling units and purpose/type of end users.

The low cost grey water treatment system takes care of major qualitative aspects through Sedimentation, Filtration [sand filter], Coagulation and Disinfection and explained as follows:

Sedimentation is a process for settling down heavier insoluble particles at the bottom, like- tea leaves settle down in cup of tea. Mud settles down in muddy water at bottom. Filtration is the process for removing particulate impurities, turbidity & bad odor by forcing grey water to pass through porous medium, like- Reverse Osmosis[R O], and sand filter. Coagulation is the process for aggregation of fine particles into larger one and float through adding electrolyte like- Alum [Fitkari]. Disinfection is the process for killing pathogenic micro-organisms, responsible for spread of water borne disease. The chlorination / sodium hypochlorite is added in grey water for disinfection purpose.

The purpose of grey water reuse also decides the nature of grey water treatment procedure. For example: [i] The water use for hostel, Mall Toilet flushing requires simple filtration and disinfection. [ii] The water use for gardening, lawn maintenance requires sedimentation and trenching. [iii] The water use for Hotel/ Restaurant Toilet flushing requires sedimentation and disinfection [9].

The grey water recycling unit is intermediate step in between grey water treatment and end-users. The clean water through grey water treatment is either collected in underground sump or overhead tank, depending upon available facility. It is transported through separate pipe line system in tap connection for washing, toilet, bathing and hand washing at individual household with slow flow rate at definite timing slot, besides in water storage tank for emergency purpose. The solar pump with attached meter may be used. It is of non-potable nature. The Potable category water is to be supplied through another distinct pipe line for Kitchen tap towards cooking, food preparation and drinking purpose – as municipal water at two different time periods, besides in water storage tank for emergency purpose. The in-coming and out-going grey water with water- meter measurement is the part of revenue collection mode for grey water management at each household.

Conclusion

Grey water has been used as supplement for domestic water supply towards saving cum conservation of precious potable water at Middle east, European countries, Australia and USA; under strict regulation. Grey water reuse in rural school of Jhabua [M P, India] has been introduced by NERRI, CSIR Lab at Nagpur in 2007 [4]. The quantity and quality norms for domestic water supply have been formulated in 2012 by Ministry of rural drinking water and BIS respectively [6]. The lab scale recycling of grey water has been studied at GHRCE, College Nagpur with its successful implementation for local residential flats in 2015 [7]. JJM has focused on grey water management-reuse, treatment at national level in 2019.

The overall emphasis on grey water has substantial role in reducing load on sewerage and domestic potable water supply of potable nature, with considering the following seven aspects:

- The major economic benefit of grey water enables to us for optimum to minimum consumption of fresh water at household level.
- The cost of grey water treatment system may be recovered within two years from its installation date, subject to is proper maintenance and operation.
- The grey water recycling unit is to be complimentary with integrated water resource management including rain water harvesting towards tackling water crisis problem.
- The grey water management may play leading role for prospective water sustainable in achieving water security.
- Environmental legislation and regulations are to be strictly enforced for grey water reuses.

- The performance of grey water generation, treatment & recycling must have separate pipe line system at household, excluding municipal water supply [potable].
- The permutation and combination of different methodologies towards treatment & recycling of grey water are to be orientated with grey water reuse pattern in order to achieve optimum benefits.

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