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Physico-Chemical Properties of Light Greywater for Residential Society in Badlapur, Thane District Maharashtra

Suresh D. Suryawanshi[1], Prof. Padmakar J Salunke[2], Prof. Shreeshail Panchu Gaikwad[3]

[1]M.E. Student, [2]Associate Professor, [3]Assistant Professor,
[1, 2, 3]SES Yadavrao Tasgaonkar College of Engineering & Management, Karjat, Maharashtra, India

ABSTRACT

Water plays a vital role and one of the basic necessities of human being. As per the report from the United Nations has estimated that in the year 2025, about 2.6 billion people will be facing water scarcity problems which mean more than half of the population will be affected by water scarcity and even it will not be exerted to say that third world war may occur due to water. [1] Water dearth has turn out to be one of the most critical problems of the current era. Some experts have also suggested that water shortage will turn out to be more severe than oil dearth in the future. The need for increased water requirement for the growing population in the new century is generally assumed, without considering whether available water resources could meet these needs in a sustainable manner.

The question about from where the extra water is to come, has led to this study. It is necessary to learn physico-chemical properties of contamination of water to understand its reuse in a residential building. It is possible to intercept this grey water, at the household level, treat it so that it can be recycled for using other purposes. In this report we are going to study the domestic light grey water i.e. washing clothes, wash basin, bathroom from day to day life of case study of residential building Mohan Willows in Bhosale Nagar, Shirgaon, Balapur. The samples were analysed for the physical and chemical characteristics of the water. The parameters examined were: pH, Turbidity, TDS, COD, BOD, Oil & Grease, Conductivity, Total Hardness, Calcium, Magnesium, Alkanity, Sulphate, Iron, Lead, Zinc, DO and Nitrate. The research showed that the quality of light greywater with respect to COD, BOD, turbidity and total hardness requires adequate treatment prior to household reuse. With regard to the trace and heavy metal contents, no further treatment is required.

KEYWORDS: *Physio-Chemical Parameters, Grey Water, Water Scarcity, Residential Building*

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1. INTRODUCTION

1.1. General

Around one-fifth of the world's population, belongs to the areas of physical scarcity of water occurs (i.e. the countries where water in scarcity form) and almost one-fourth of the world's population, faces economic water lack (i.e., the countries that lack the necessary infrastructure to obtain water from rivers and aquifers). The world population has been rising at a pace of about 1% per year, similarly other infusing factors like economic growth, changing lifestyle patterns (due to pandemic diseases like covid-19) will continue to grow, and resulting in water scarcity in various parts of the world. [2]

Residential water consumption approximately makes up 10% of overall water consumption, preceded only by water consumed by agricultural irrigation and water consumption by industries. Building industry practitioners like Designers and Engineers have begun to pay consideration to scheming and controlling the ecological damage due to their activities. Particularly civil engineers have a unique opportunity to reduce ecological impact through treating the greywater at the course only.

Domestic wastewater can contain physical, chemical and biological pollutants. Broadly we can classify waste water as blackwater and greywater. Black water can contain feces, urine, water and toilet paper from flush toilets. Black water is distinguished from grey water, which comes from kitchen sinks, bathrooms, washing machines, and other kitchen appliances apart from toilets. Greywater can be further categorized based on the source of waste like light greywater and dark grey water. In the recent past, there is comparatively increased awareness among the governments and bodies dealing with water management to address the challenges related to water security. Measures to reduce water usage through increased awareness, installation of rainwater harvesting and grey water (GW) treatment systems are seen as promising solutions, especially in developing countries that are more vulnerable to water scarcity like India. Water is an essential part of human's life. In water shortages, three key methods: water conservation, desalination and recycling could be considered. Due to lower costs and possibility of wastewater treatment in waste production site, water recycling is much better than the other two methods. Greywater reuse is increasingly emerging as an integral part of water demand management. [3, 4]

1.2. Aim and Objective

Aim: "The ultimate aim of this work is to systematically understand the physicochemical parameters of light grey water generated from bathroom, wash basin & washing machine and its scope of reuse for a residential building".

Objective: The research objectives for execution of thesis are as follows:

1. To study and understand physico-chemical properties of light grey water of case study building.
2. To study scope of reuse of light greywater in case study building.

2. LITERATURE REVIEW

A literature review of scholarly articles, books, dissertations, conference proceedings and other resources which are relevant to the study of light greywater effluent, carried out to set the background on what has been explored on the topic so far. An extensive literature review provides background information on current knowledge related to the research topic.

Table No. 1: Characteristics of Effluent from Various Research Paper

Sr. No.	Paper	Year of Publication	Remarks	
			Characteristics of Laundry Effluent	Value
1.	Commercial Laundry Water Characterization by J. K. Braga and M. B. A. Varesche	2015	pH	5.6
			Total Alkalinity	25.9
			COD	1710
			TSS	80
			Nitrate	8.4
			Nitrite	2.1
			Sulphate	21.1
			Sulphide	0.2
2.	Characterization of domestic gray water from point source to determine the potential for urban residential reuse by Golda A. Edwin Et. al	2017	pH	9.1
			EC	641.6
			Hardness	721
			BOD_5	186.5
			COD	1545.8
			DO	N.D
			TS	586
			TSS	141.2
			Nitrate	0.3
			Nitrite	0.2
3.	Study of physico-chemical characteristics of domestic Wastewater in Vishnupuri, Nanded, India by Sonune NA Et. al	2019	pH	7 – 8
			BOD	56 – 96
			COD	180 – 300
			Ammonical Nitrogen	129 – 146
			Nitrate	74 – 181

			Phosphate	0.4 – 2.1
			TDS	1228 – 1440
			TSS	43 – 65.43
4	Qualitative Characterization of Greywater from a Residential Complex in Bengaluru City, Karnataka, India by Parameshwara Murthy Et. al	2019	pH	5.7
			BOD	35-138
			COD	123 - 540
			Nitrate	0.67 – 2.3
			Phosphate	6 – 12.8
			TDS	144 - 212
			TSS	86 - 300
5	Characteristics and Treatment of Greywater – A Review	2021	pH	7 -7.3
			BOD	155 - 205
			COD	386 - 587
			Total N	6.6 – 10.4
			Total P	0.69 – 1.1
			TDS	215 - 279
			TSS	153 - 259

3. METHODOLOGY

At preliminary level the research work will be carried out to identify the reusability of waste water in residential building by studying to the physico-chemical parameters of light grey effluent and particularizing the scope of reuse of same waste water for multipurpose uses like vechile washing, house & society cleaning, gardening etc.

4. CASE STUDY

4.1. Case Study Details

Primarily the data will be collected from case study that is residential building - Mohan Willows, Bhosale Nagar, Shirgoan, Badlapur(E) . Data will be composed in the form of survey from all the households of the case study building.

Building Name	Mohan Willows Phase II, Ashwood building
Address	Bopkhel, Vishrantwadi, Pune - 411031
Total No of flats	131
Data Collection Period	April - May 2022

4.2. Case Study Location

Badlapur is a beautiful city in the district of Thane in the Indian state of Maharashtra. Badlapur is in proximity with Mumbai, Navi Mumbai, Kalyan, Panvel and Karjat locations. The city is having decent infrastructural amenities with beautiful natural view. The latitude and longitude of study area is 19°15'48.7"N, 73°23'13"E.

Figure No. 1: Showing Map of Case Study Area

4.3. Method Used for Analysis

Grey wastewater samples were characterised to determine the physical and chemical parameters. Some physical test should be performed for testing of its physical appearance such as colour, pH, turbidity, TDS, while chemical tests should be perform for its COD, BOD, Oil & Grease, Conductivity, Total Hardness, Calcium, Magnesium, dissolved oxygen, alkalinity, Sulphate, Iron, Lead, Zinc, DO and Nitrate. All parameters were analysed in accordance with standard method for the examination of water and wastewater.

Table No. 2: Physico-chemical Parameters and Methods Adopted for the Analysis

Sr. No.	Analysis Parameters	Method used
01	pH	pH meter, IS: 3025 (part – 11 – 2): Reaff. 2012
02	COD	IS: 3025 (part – 58): Reaff. 2014
03	BOD	IS: 3025 (part – 44): Reaff. 2014
04	Oil and Grease	IS: 3025 (part – 39- 5): Reaff. 2014
05	Turbidity	Nephelometer, IS: 3025 (part – 10): Reaff. 2012
06	Conductivity	Conductivity meter IS: 3025 (part – 14): Reaff. 2013
07	Total Dissolved Solids	Gravimetric Method, IS: 3025 (part – 16): Reaff. 2012
08	Total Hardness	Titrimetric Method, IS: 3025 (part – 21- 2): Reaff. 2014
09	Calcium	Titrimetric Method, IS: 3025 (part – 40- 5): Reaff. 2014
10	Magnesium	Titrimetric Method, IS: 3025 (part – 46- 6): Reaff. 2014
11	Total Alkalinity	Titrimetric Method IS: 3025 (part – 23): Reaff. 2014
12	Sulphate	Spectrometer IS: 3025 (part – 24- 4): Reaff. 2014
13	Iron	Spectrometer IS: 3025 (part – 53- 6): Reaff. 2014
14	Lead	Atomic Absorption, APHA 3111 - D
15	Zinc	Atomic Absorption, APHA 3111 - D
16	Dissolved Oxygen	Atomic Absorption IS: 3025 (part – 44): Reaff. 2003
17	Nitrate	IS 3025 (Part 34): Reaff. 2014

4.4. Analysis of Physico-chemical Properties

The sample analyses of the collected greywater are represented in to the tabular form in following section.

Table No. 3: Physico-chemical analysis of light greywater effluent

Sr. No	Analysis Parameters	Samples										Mean
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
1	pH	9.6	8.4	8.4	9.3	9.6	9.1	9.1	9.2	8.8	8.9	9.0
2	COD	1512	1551	1769	1546	1431	1535.0	1572	1545	1493	1520	1547.4
3	BOD	154	167	167	189	193	181.6	187.5	181	189	184	179.3
4	Oil and Grease	3.6	3.9	ND	ND	ND	ND	ND	4.3	ND	6.3	1.8
5	Turbidity	118.7	111.5	98	100.5	77.1	106.3	81.7	105.1	110.6	169.5	107.9
6	Conductivity	700.6	533.4	551.2	687.2	687.7	641.2	624	631.9	695.1	647.5	640.0
7	TDS	701	712.5	722	728	740	708.0	710	722.4	751.1	732.3	722.7
8	Total Hardness	637	582	572	629	637	611.6	628	645	660	614	621.6
9	Calcium	3.9	3.9	3.2	3.7	4.2	4.1	4.1	4.2	4.9	4.1	4.0
10	Magnesium	1.5	1.1	0.9	1.32	1.6	1.3	1.3	1.41	1.6	1.6	1.4
11	Total Alkalinity	36.5	37	31.2	39.21	43	36.7	32.8	32.7	38.7	39.4	36.7
12	Sulphate	24.8	22.1	21.2	25.2	28.1	25.3	26.7	27.3	25.9	26.2	25.3
13	Iron	ND	1.14	0.9	ND	0.77	0.8	1.2	1.12	ND	1.3	0.7
14	Lead	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
15	Zinc	ND	<0.01	ND	<0.01	<0.01	<0.01	<0.01	ND	ND	<0.01	<0.01
16	Dissolved Oxygen	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
17	Nitrate	0.1	0.2	0.1	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.2

The classical use of light greywater analysis of residential building is to produce information concerning the water quality and scope of reuse of waste water. The waste water quality may yield information about the environment through which it been reused and the treatment required for recycling the water. The physicochemical composition of collected samples was statistically analyzed and presented in below section.

pH:-The pH value of water is very important indicator of its quality. The pH values of water are controlled by the amount of dissolved carbon dioxide, carbonate and bicarbonates. pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. The pH values of water samples vary between 8.4 to 9.6 and some of the values were not found within the limit prescribed by BIS and WHO.

Chemical Oxygen Demand (COD):-Is an indicative measure of the amount of oxygen that can be consumed by reactions in a sample solution. It is commonly expressed in mass of oxygen consumed over volume of solution which in SI units is milligrams per liter (mg/L). A COD test can be used to easily quantify the amount of organics in water. The concentration of COD varied from 1431 mg/l to 1769 mg/l. High COD value in effluent shows the presence of oxidisable organic materials. High COD concentration in samples indicates the presence of organic contaminants in the water to a large extent.

Biochemical Oxygen Demand (BOD):-Also known as biological oxygen demand is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value in this study has been expressed in milligrams of oxygen consumed per liter of sample during 3 days of incubation at 27 °C. BOD concentration of these samples is ranged from 154 mg/l to 193 mg/l. High BOD concentration in effluent of waste water samples indicates the presence of organic contaminants in the water.

Oil and Grease: - Oil and grease is also a major threat to surface and ground water through infiltration and seepage, thereby reducing the quality of the affected resources. Oil and grease concentration is ranged from 3.6 mg/l to 6.3 mg/l. In 60% of the samples it is not detected and in remaining 40% it is detected.

Turbidity: - Turbidity in water is the reduction of transparency due to the presence of particulate matter such as dirt or slit, finely divided organic matter etc. These can cause light to be scattered or absorbed rather than transmitted in straight lines through the sample. The turbidity was due to the colloidal fine dispersion of suspended solids. Some microorganism might also contribute the turbidity. In present study turbidity was found between 81.7 NTU to 169.5 NTU. The values were found with high values then that prescribed by IS: 10500.

Conductivity: -The conductivity values varied from 533.4 µs/cm to 700.6 µs/cm in the samples analysed from the respective case study. Electrical conductivity gives an idea about the concentration of ions in solution that determines the quality of water for reuse purposes.

Total Dissolved Solids (TDS):- TDS is generally considered not as a primary pollutant, but it is rather used as an indication of aesthetic characteristics of water and as an aggregate indicator of presence of a broad array of chemical contaminants. Total dissolved solids indicate the salinity behaviour of grey water. Water containing more than500 mg/L of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/L is also allowed. The amount of Total Dissolved Solids varied from 701 mg/lit to 751.1 mg/L in study of collected samples.

Total Hardness:- Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water. Hardness is one of the important properties of grey water from utility point of view for different purposes. In grey water, hardness is primarily due to presence of carbonates, bicarbonates, sulphates and chlorides of calcium and magnesium. For potable water the TH should be limited up to 300 mg/L and maximum permissible value is 600 mg/L. If the hardness is less than 50 mg/l the water will be soft. If the hardness is from 50 mg/lit to 100 mg/l, the water will be moderate soft. If the hardness is from 101 mg/lit to 200 mg/l and more than 200 mg/l, the water will be slightly hard and quite hard, respectively. In the analysis total hardness values were ranged between 572 to 660 mg/L. Again the study confirmed the excess quantity of hardness creating cations and anions were present in and around the grey water samples.

Calcium:- Calcium is the most abundant of the alkaline earth minerals. Calcium is directly related to hardness. The concentration up to 100 mg/l of calcium is capable of forming scales in pipes and boiler; fortunately it has no adverse physiological manifestation on human system. Calcium is the third most abundant metal in the earth's crust. Excess of ca ions causes concretions in the kidney and causes irritation and pain in the urinary passages. The Ca concentration was ranged between 3.2 mg/lit – 4.9 mg/lit and found below permissible limit.

Magnesium: - The WHO standards prescribed the limit for the presence of magnesium in water is 50 – 100 mg/l. The concentration of magnesium ranged between 0.9 to 1.6 mg/l. High concentration of Mg can cause laxative effect in human being but in our case it is within the permissible limit.

Total Alkalinity: - Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. Total alkalinity values for all the investigated samples were found in the range of 31.2 to 39.4 mg/l.

Sulphate: - Sulphate can be found in almost all natural water. The origin of most sulphate compounds is the oxidation of sulphite ores, the presence of shales, or the industrial wastes. Sulphate is one of the major dissolved components of rain. High concentrations of sulphate in the water we drink can have a laxative effect when combined with calcium and magnesium, the two most common constituents of hardness. The Sulphates concentration of grey water samples ranged between is 21.2 mg/L to 28.1 mg/L and found within the prescribed limit.

Iron:- High iron concentrations generally cause a bitter and astringent taste. It also clogs and pits pipes, discolors clothes and plumbing fixtures and causes scaling which encrusts pipes. The values for all the investigated samples were found to be in the range of 0.77 mg/L to 1.3 mg/L which is within the permissible limit of BIS and WHO (i.e. 5 mg/L).

Lead: - Lead is a toxic metal that is harmful to human health; there is no safe level for lead exposure. The degree of exposure depends on the concentration of lead, route of exposure, current medical condition, and age. It has been estimated that up to 20 % of the total lead exposure in children can be attributed to a waterborne route, i.e., consuming contaminated water. The permissible limit BIS and WHO (i.e. 0.01 mg/L) for drinking and for recycle/reuse the permissible limit is 0.5 mg/L. In the study area analysis the lead has been detected in some sample bit at very low value of less than 0.003 mg/L

Zinc: - Zinc is an essential mineral, including to prenatal and postnatal development. Zinc deficiency affects about two billion people in the developing world and is associated with many diseases. In children, deficiency causes growth retardation, delayed sexual maturation, infection susceptibility, and diarrhea. Consumption of excess zinc can cause ataxia, lethargy and copper deficiency. In the study area analysis the zinc concentration has been detected in some sample bit at very low value of less than 0.001 mg/L.

Dissolved Oxygen: -Dissolved oxygen is important parameter in water quality assessment and reflects the physical and biological processes prevailing in water. The DO values indicate the degree of pollution in grey water. In the analysis all the samples, the concentrations of DO is not at all detected.

Nitrate: - The excess levels can cause methemoglobinemia, or "blue baby" disease. Although nitrate levels that affect infants do not pose a direct threat to older children and adults, they do indicate the possible presence of other more serious residential contaminants, such as bacteria or some kinds of pesticides. The permissible limit for the nitrate is 30 - 45 mg/L. The nitrates concentration of groundwater samples were very low than the permissible limit.

5. CONCLUSION

In case study building, the characteristics of light greywater were evaluated using wastewater samples (10 numbers) of case study building. The samples were analysed for the physical and chemical characteristics of the water. The parameters examined were: pH, Turbidity, TDS, COD, BOD, Oil & Grease, Conductivity, Total Hardness, Calcium, Magnesium, Alkanity, Sulphate, Iron, Lead, Zinc, DO and Nitrate. The research showed that the quality of light greywater with respect to COD, BOD, turbidity and total hardness requires adequate treatment prior to household reuse. With regard to the trace and heavy metal contents, no further treatment is required.

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