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"Analysis and Treatment of Domestic Waste Water and its Reuse for Irrigation"

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Abstract: *Water has already become a scarce resource in many parts of the world. This is due to rapid population growth and industrialization; lifestyle changes the thoughtless pollution of good water. Global warming and climate change will be the additional factors in the future. Water conservation and reuse are therefore becoming more and more important. Domestic waste water contains organic and inorganic matter in suspended, colloidal and dissolved forms. The concentration in the waste water depends on the original concentration in the water supply and the uses to which the water has been put. The present study deals with analysis and reuse of domestic waste water. For agricultural reuse the waste water may need to undergo the usual preliminary, primary and secondary treatment steps, generally undertaken to make the waste water fit for reuse or discharge to the environment.*
Key Words: *Water scarcity, Collection & Analysis of Domestic waste water, reuse of waste water, water treatment, irrigation.*

I. Introduction

The scarcity of good quality irrigation water is a serious problem in arid and semi arid zones of India. The surface water resources are generally meager. Irrigated agriculture in arid zones is largely dependent on ground water resources which are commonly saline in nature **[1].** At the same time with population expanding at a high rate the need for increased food production is apparent. The potential for irrigation to raise both agricultural productivity and the living standards of the rural poor has been recognized. **[2]**Whenever good quality water is scarce water of marginal quality or domestic waste water will have to be considered for use in agriculture purpose. Plants differ widely in their ability to grow and develop under saline conditions. Some crops are very sensitive to salinity while others are tolerant. The properly planned use of domestic waste water decreases the surface water pollution problems and conserves valuable water resources. The water used for irrigation purpose is must be free from soluble salts and from concentrations of specific chemical substances that may be a hazard to soil with respect to salinity, sodium salts and toxicity. The characteristics of irrigation water that appear to be most important to determine its quality depends upon climate conditions, irrigation practices, soil-water receptivity characteristics, crop tolerance, depth to water table and agronomic practices are following:

1. Electrical Conductivity (EC) or Salinity Hazard: The total concentration of soluble salts the most important parameter used for determining quality of irrigation water. It is measured quantitatively in terms of "Electrical Conductivity (EC)" because it is very closely related to the sum of major cations or anions. Total salt concentration is expressed in milligrams per liter or parts per million where as electrical conductivity is expressed in decisiemen per meter (ds/m).

3. Sodium Adsorption Ratio (SAR): United salinity laboratory (USSL)**[3]** proposed for the first time a better index called sodium adsorption ratio (SAR) to determine sodicity hazard of irrigation waters. The SAR is defined by the following formula:

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}}$$

Where the ionic concentrations are expressed in me/l.

4. Residual Sodium Carbonate (RSC): Bicarbonate concentration is related to the concentration of calcium + magnesium, residual sodium carbonate (RSC). Development of alkali **[4]** soils may be expected when irrigation water containing CO_3^{-2} + H CO_3^- higher than Ca+Mg is used for irrigation provided that it is used so sparingly that little leaching occurs. In water containing high concentrations of bicarbonate ion there is tendency for calcium and to some extant for magnesium to precipitates as carbonates as the soil solution becomes more concentrated. The precipitation of calcium as a scale in distribution lines, boilers, water heaters and other equipment is a common observation. The same reaction can take place when irrigation water is applied to soil. As calcium precipitates the ratio of sodium to calcium increases with a corresponding increase in the SAR value. Bicarbonate waters therefore were considered to accumulate sodicity hazard as determined from SAR.

USSL **[3]** derived an index called Residual Sodium Carbonate to determine alkalinity hazard to be calculated as follows and expressed in mmol/l.

$RSC = (CO_3^{-2} + HCO_3^{-}) - (Ca^{+2} + Mg^{+2})$.

The water containing RSC<1.25, 1.25-2.5 and >2.5 mmol/l were considered as safe, marginal and unsuitable respectively.

2. Soluble Sodium Percentage (SSP):

For some time in the past the quality of irrigation water used to be determined on the basis of soluble sodium percentage (SSP), in addition to salinity. It is used to be calculated by using following formula:

$$SSP = \frac{\text{Soluble Sodium Concentration}}{\text{Total Cation Concentration}} \text{ X } 100$$

Evaluation of quality of water on the basis physical and chemical parameters is as follows **[1]**

1.1Water Quality

1. Excellent Water: EC=0.2-1.5 ds/m, SAR= 5-10 meq/l,RSC= 0 meq/l and SSP <20

Remark: Water and can be used for irrigation with most crops on most soils

2. Good Water: EC=1.5-3.0 ds/m, SAR =10-20 meq/l, RSC =Trace 2.5 meq/l and SSP =20-40

Remark: Can be used for irrigation if a moderate amount of leaching occurs under the current irrigation practices.

3. Permissible Water: EC=3.0-5.0 ds/m, SAR =20-30 meq/l ,RSC =2.5-5.0 meq/l and SSP =40-60

Remark: Water can be used for irrigation on soils provided with: good drainage such that leaching fraction is not < 0.3; only for crops which are tolerant to sodium on soils provided with good drainage such that LF is always>0.3 and almost all soils with little danger of development of harmful levels of alkali for growing all crops except specially sensitive to carbonate and bicarbonates.

4. Doubtful water: EC=5.0-10.0 ds/m, SAR =30-40 meq/l, RSC= 5-10 meq/l, SSP =60-80

Remark: Water cannot be suitable for irrigation but may be used in cycle or in conjunction with low sodicity waters or with amendments such as gypsum with very good drainage so that leaching fraction is always >0.3.

5. Undesirable water:EC>10 ds/m, SAR >40 meq/l, RSC >10 meq/l and SSP >80.

Remark: Water cannot be suitable for irrigation but may be used in cycle or in conjunction with low salinity waters & with low alkalinity waters or with amendments such as gypsum.

II. Materials And Methods:

2.1 Collection of Domestic Waste Water Sample: The physical and chemical characteristics of sewage vary from top to bottom of sewage depth as well as with time as from morning to evening. It therefore becomes difficult to obtain a truly representative sample. Samples were collected at a point beneath the surface where the turbulence is thoroughly mixing up the sewerage particles. These grab samples were collected at regular time intervals during a day. These different samples were mixed together. This composite sample is taken for testing because it represents the true strength of the waste water**.[5]**

2.2 Analysis of pH: The pH of a solution is the negative logarithm of the hydrogen ion activity, which may be measured potentiometrically. The determination of the pH value is carried out by measurement of the potential difference between electrodes immersed in standard and test solutions. The standard solutions used are assigned a definite pH value by convention. As pH values are dependent on temperature, the measurements are carried out at selected constant temperatures.

2.3 Analysis of EC: Electrical conductivity of water sample is determined by conductivity meter. This instrument has a conductivity cell. The cell constant of this cell is determined first by measuring the conductance of standard KCl solution, specific conductance of which solution is known.

$$\text{Cell Costant} = \frac{\text{Known sp. conductance of std. KCl solution}}{\text{Conductance shown by the cell}}$$

The conductance of water sample is measured with this standardized instrument and the obtained conductance value multiplied by cell constant gives the EC value of the sample.

2.4 Analysis of Cations:

2.4.1 Ca^{+2} & Mg^{+2}Analysis: EDTA is a very efficient complexone which form chelates with a number of polyvalent cations. This behavior is utilized to determine the concentration of calcium and magnesium ions using EBT as an indicator in the water sample.

2.4.2 Na^{+} and K^{+} Analysis: Na and K can be estimated by flame photometric analysis. Flame photometry involves emission of typically colored flame from the basic ions. Intensity of which are measured through a galvanometer. Ti is a rapid method and can be carried out with small amount of water sample.

2.5 Analysis of Anions:

2.5.1 CO_3^{2-} & HCO_3^{-} Analysis: The alkalinity of water is normally due to the presence of bicarbonates, carbonates and hydroxides of sodium, potassium, calcium and magnesium. A known volume of the sample is titrated against a standard acid solution using phenolphthalein as an indicator and the sample is again titrated against the same standard acid using methyl orange as an indicator, alkalinity is found in terms of $CaCO_3$ equivalents in both the cases. From the measurement of phenolphthalein alkalinity and methyl orange alkalinity it is possible to calculate the magnitude of various forms of alkalinity present in water sample.

$$\left.\begin{array}{l} \left.\begin{array}{l} OH^- + H^+ \rightarrow H_2O \\ CO_3^{2-} + H^+ \rightarrow HCO_3^- \end{array}\right\}[P] \\ HCO_3^- + H^+ \rightarrow H_2CO_3 \end{array}\right\}[M]$$

CO_3^{2-} =2P and HCO_3^- = (M-2P)

2.5.2 Cl^- Analysis: Chloride ions can be determined by Argentometric method. The titration of the water sample against a standard solution of $AgNO_3$ using potassium chromate as an indicator in a natural or faintly alkaline medium. When $AgNO_3$ solution is added to the water sample in presence of $K_2Cr_2O_7$ the chlorides present in it are precipitated as AgCl. As soon as all the chlorides are precipitated out even a drop of $AgNO_3$ added in excess gives a red precipitated of silver chromate. This indicates the end point.

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

2.5.3 SO_4^{2-} Analysis: Sulphate ions can be determined by gravimetric method. Barium chloride solution of known concentration is added in excess to precipitate barium sulfate and the precipitate is digested in the hot solution. The precipitate is filtered through a ash less filter paper which is then ignited and completely ashed. From the volume of the sample and weight of the precipitate, the concentration of sulfate in the sample is calculated. The precipitation reaction is the following:

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

2.6 Analysis of Sodium Absorption Ratio (SAR): The SAR is a term used to express the relative concentration of Na ions over divalent cation viz. Ca and Mg and calculated as follows.

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}}$$

2.7 Analysis of Soluble Sodium Carbonate (SSP): The proportion of Na ions in water with relation to total cations concentration is termed as soluble sodium percentage and calculated as follows.

$$SSP = \frac{\text{Soluble Sodium Concentration}}{\text{Total Cation Concentration}} \times 100$$

2.8 Analysis of Residual Sodium Carbonate (RSC):

$RSC = (CO_3^{-2} + HCO_3^-) - (Ca^{+2} + Mg^{+2})$.

III. Result & Discussion

a. Physical and chemical parameters of domestic and sewage waste water samples are presented inTable-1.

Table-1 Analysis of Domestic, Sewage & Mixture of Domestic (50%)+Sewage(50%)Waste Water Samples

1. S-1 Waste Water from Hostel Mess
2. S-2 Waster Water from Hostel Sewage
3. S-3 50% Waste Water from Hostel Mess + 50% Waster Water from Hostel Sewage

S.No.	Parameters for Analysis	Std. Values	S-1	S-2	S-3
1.	pH	6.5-8.0	6.0	6.2	6.2
2.	EC at 25^0C in ds/m	3.0-5.0	4.94	4.38	4.33
	Cations (Meq/l)				
3.	$Ca^{+2} + Mg^{+2}$	-	14.2	1.6	4.8
4.	Na^+	-	32.0	38.0	35.3
5.	K^+	-	3.2	4.2	3.2
	Anions (Meq/l)				
6.	$CO_3^{-2} + HCO_3^-$	-	13.0	18.0	16.2
7.	Cl^-	-	32.2	22.0	23.1
8.	SO_4^{-2}	-	4.2	3.8	16.2
	Others				
9.	SAR	Up to 10(Meq/l)	12.03	42.69	22.92
10.	SSP	Up to 50(Meq/l)	64.77	86.75	81.52
11.	RSC	Up to 2.5(Meq/l)	NIL	16.4	11.4

1. Electrical conductivity values of all three samples were found below std. value.
2. Sodium Absorption Ration and Soluble sodium percentage values of s-1 was found very close to standard value but of S-2 and S-3 were found very high.
3. Residual sodium carbonate value of S-1 was found very satisfactory but of S-2 and S-3 were found very high.
4. Domestic waste water was selected for further study.

b. Domestic waste water samples were collected from Monday to Sunday according to same procedure described in section2.1. Total 7 samples + mixture of all 7 samples (100 ml each sample) =8 samples were analyzed.

c. Physical and chemical parameters of 8 domestic waste water samples presented in Table-2.

Table-2 Day wise analysis of Domestic Waste Water

Waste water samples from boys mess were collected day wise for analysis.

Coding:	Collection Day	Code	Collection Day	Code	Collection Day	Code
	Monday	S-1	Tuesday	S-2	Wednesday	S-3
	Thursday	S-4	Friday	S-5	Saturday	S-6
	Sunday	S-7	Mix of all 7 days in equal ratio			S-8

All above samples were collected from 30th June 2014 to 6th July 2014.

Parameters	Std.Value	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
pH	6.5-8.0	6.5	6.5	6.9	6.1	6.1	6.0	6.8	6.8
EC at 25^0C in ds/m	3.0-5.0	4.61	4.70	4.77	4.74	4.48	5.96	4.29	4.72
Cations (Meq/l)									
$Ca^{+2} + Mg^{+2}$	-	22.6	25.6	24.2	33.6	23.8	12.8	22.8	25.0
Na^+	-	19.8	20.2	19.3	13.8	18.9	13.9	17.3	20.0
K^+	-	3.7	1.2	4.3	nil	2.1	2.9	2.8	2.2
Anions(Meq/l)									
$CO_3^{-2} + HCO_3^-$	-	14.8	13.2	17.0	15.8	14.0	13.4	9.2	23.4
Cl^-	-	28.6	26.7	25.0	26.5	26.5	24.1	27.4	20.4
SO_4^{-2}	-	2.7	7.1	5.7	5.1	4.3	2.1	6.3	3.8
Others									
SAR	Up to 10(Meq/l)	5.57	5.75	5.54	3.96	5.47	5.49	5.01	5.05
SSP	Up to 50 (Meq/l)	42.95	42.97	40.46	29.11	42.18	43.65	40.32	42.37
RSC	Up to 2.5 (Meq/l)	nil	nil	Nil	nil	nil	nil	nil	nil

1. Electrical conductivity values of all eight samples except S-6 was found below std. value.
2. Sodium absorption values of all eight samples were found below std. value.
3. Soluble sodium percentage values of all eight samples were found below std. value.
4. Residual sodium carbonate values of all eight samples were found below std. value.
5. Alkalinity values of all samples were found very high which requires treatment with gypsum.

IV. Conclusion

Domestic waste water from boys hostel mess can be used for irrigation after treatment with 1-2% gypsum. For the treatment of waste water conventional treatment process is used which consists of three stages of treatment process.

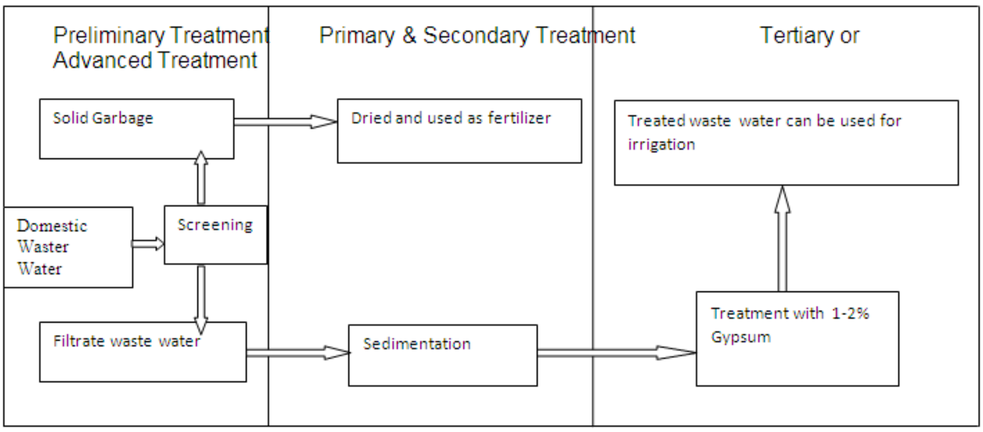
4.1Preliminary Treatment: This step consists of screening to remove coarse solids and other large materials present in waste water. In the present study after removal of coarse particles or garbage from mess after drying in UV rays is used as fertilizers.

4.2Primary & Secondary Treatment: This step consist the removal of settleable organic and inorganic solids by sedimentation and removal of floating materials by skimming.

4.3Tertiary or Advanced Treatment: This step consist the decrease in alkalinity value by 1-2% gypsum addition. Addition of gypsum also improves the SAR and RSC level.

4.4Use of dried garbage as Fertilizer: After filtration of waste water insoluble domestic waste or garbage is dried and used as a fertilizer for crops.

Flow Chart of Waste Water Treatment Method



After treatment of waste water it can be used for irrigation of Neem and Basil(Tulsi).

Saline water or waste water with excessively high salinity sometimes cannot be used beneficially for agriculture. Innovations reveals that such type of waters may find a useful application in the fields like fish farming, fish cum rice farming and growing of halophytes.

Central Institute of Fisheries Education (CIFE), ICAR have developed a Brackish Water Fish Farm at Karnataka, Andhra Pradesh, India.

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