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AN EXPERIMENTAL STUDY TO EVALUATE THE EFFECTIVENESS OF S*PHATIKA* MENTIONED IN *SUSHRUTHA SAMHITA* IN THE PURIFICATION OF CONTAMINATED WATER W.S.R. TO POTASH ALUM.

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ABSTRACT:

Introduction: Water is vital for the existence and maintenance of health of all the organisms on earth. There has been an exponential rise in global population while the supply of water has remained constant and its demand is increasing at an alarming rate. Around 70% of the earth's surface is covered with water. However, around 1% of it is only suitable for human consumption. The water pollution is increasing rapidly, degrading the quality of water. Consumption of unsafe water ismajor cause of water borne diseases. Hence, it is very essential that water should be pure. For this need, the attempt has been made to evaluate the effectiveness of *Sphatika* (Potash alum) in the purification of contaminated water which is cost effective and simple technique. **Aims and Objectives:** To carry out the experiment of *Jalaprasadana* using *Sphatika* to evaluate its efficacy on contaminated water. **Methodology:** Water samples were collected from the unused well. The water was taken in a glass bottle of 500ml; 1st group was used without any materials and treatment methods. Second group was subjected to filtration. Third group was added with *Sphatika* (potash alum) in the quantity of 10, 25 and 50 grams. Each of the samples were assessed after 6, 12 and 24 hrs; for the physical, chemical and microbial parameters and compared with the standard values. **Results:** After adding of potash alum, the study showed significant increase in DO and Salinity; significant decrease in pH, Conductivity, TDS, Turbidity, TA, Carbonate and Bicarbonate. Bacterial colony count had shown depletion after adding of Potash alum. **Conclusion:** Potash alum showed positive results in the purification of water. Potash alum is soluble in water, thus can be used as coagulating and flocculating agent and can be applied prior to sedimentation and filtration process to enhance the ability of a water treatment.

KEYWORDS: Water; *Sphatika*; Potash alum; Contaminated water; Water Purification

INTRODUCTION:

Water is one of five elementary substances along with Earth, Air, Space and Fire. Water is a precious and vital natural resource which forms the basis of all life. About 70% of the human body is water. Water covers about 71% of the earth's surface but only 1.7% is available as surface water [1]. It is very important factor in the life of an individual both directly and indirectly. We are using water for direct purposes that includes bathing, drinking, cooking, etc and indirect purposes like for processing wood to make paper and in producing steel for automobiles. It is essential for digestion of food, regulation of body temperature, removal of the wastes from the body, fight against several diseases like constipation, kidney stones, UTI, etc. aids in cognitive function, etc. Hence, it is very essential that it should be pure and does not cause any harm to health [2].

In Ayurveda, *Jala* (water) is considered as one of the *Panchamahabhoota*. Evolution of life begins with water. As water is most vital for the existence of life, it is the first substance mentioned in the description of liquids. It is explained under the context of *Jalavarga*/*Paniyavarga/ Toya varga* by various scholars. In our classics, rain water called as *Divya* or *AntarikshaJala* is considered to be the best among all the sources of water and is suitable for drinking and other purposes [3]. The ancient literatures also highlighted the importance of water along with its properties.

A safe water supply is the backbone of a healthy economy, yet is woefully under prioritized, globally. The water available these days is from various sources. As the source changes the quality of water also changes. Water impurities are natural and man-made, caused by urbanization and industrialization. Less than 50 percent of the population in India has access to safely managed drinking water. Moreover, 2/3rd of India's 718 districts are affected by extreme water depletion, and the current lack of planning for water safety [4]. Consumption of unsafe water is major cause of water borne diseases worldwide. Areas with poor sanitation, inadequate supply and unhygienic practices have a high probability of waterborne diseases. If left untreated, these could translate into larger outbreak, causing a public health emergency. Annually about 37.7 million Indians are affected by waterborne diseases and 1.5 million children die of diarrhea. Moreover, 10,738 deaths occur due to various waterborne diseases over the last five years since 2017[5]. Reducing the incidence of waterborne diseases is only possible by providing access to safe and affordable drinking water. In Ayurvedic classics, water impurities are mentioned as one of the cause

of *Janapadodhwamsavyadhi* [6]. It affects large group of people or community at a time. The main cause for *Janapadodwansa* is said to be *Adharma* (unrighteousness) done by humans, which arise from the sinful acts done in both past and this life, but the source for both is *Pragnaparadha* (intellectual blasphemy) [7]. The water when vitiated or polluted will possess features like *Vikruta Gandha*, *Varna*, *Rasa* and *Sparsha, Kledabahula*, birds and aquatic animals gone away from it or has disappeared and unpleasant or disagreeable [8]. Methods and materials for purification of such contaminated water have been described in our classics, which can effectively used even today with some modifications. Methods such as boiling, exposure to sunrays, dipping of red hot iron balls in the polluted water, filtration by using cloth, and sand, small and big pebbles were common in ancient days[9].*Acharya Sushruta* has mentioned seven materials to be used for purification of *Kalusha Jala* (polluted water). They are *Kataka* (*Strychnos potatorum*), *Gomeda* (gemstone), *Bisagranthi* (lotus root)*, Shaivala moola* (*Ceratophyllum demersum*), *Vastra* (cloth)*, Mukta (*pearl)*, and Mani* [10]. For *Mani, Acharya Dalhana* commented as *Sphatika*. *Sphatika* means both Potash alum (very famous for its water cleansing activity) and Quartz (rock crystal). This has the wide scope of research. Therefore, keeping this under consideration "An experimental study to evaluate the effectiveness of *Sphatika* mentioned in *Sushrutha Samhita* in the purification of contaminated water w.s.r to potash alum" was chosen to evaluate scientific background and the efficacy towards water purification, which may be affordable, simple, easiest way and can be used by anyone, anywhere without depending upon any instruments or technical assets so that pure and safe drinking water reaches to each and every house.

MATERIALS AND METHODS:

The experiment was meant to study the efficacy of *Sphatika* (potash alum) in the purification of contaminated water, mentioned in *Sushruta Samhita*. Before conducting the experiment, the procedure to be followed had confirmed and a new experiment had designed for that. *Sphatika* (Potash alum) was immersed in the water sample and had seen for the changes occurring in the water. The time for which the *Sphatika* need to be immersed was unknown. The volume of water which would get purified with certain amount of *Sphatika* was unknown. Quantity of *Sphatika* to be added for the purification and the suitable vessel in which the experiment need to be carried was also unknown. So, the experiment had

designed in such a way that all these aspects were taken into due consideration.

a) Sample:

- Sample (raw water) had collected in the month of October from an unused, polluted well which satisfied the inclusion criteria.
- Potash alum was collected from an authentic source which was of best quality.

b) Inclusion Criteria:

- Contaminated water from natural source (common well).
- Water sample having turbidity from 2-5 NTU.

c) Exclusion Criteria:

- Water treated with Chemical purifying agents.
- Water from other sources like tap water, river water, lake water, etc.

d) Vessel:

- For the experiment, Glass bottle of 500 ml had been selected as it is inert and won't react with the substances used in an experiment.

e) Time of immersion:

- Time of immersion had considered as 6, 12 and 24 hrs.
- The time intervals had compared with each other for efficacy.

f) Quantity of water and weight of *Sphatika*:

- 500 ml of water sample was considered for the experiment.
- 10, 25 and 50 grams had been selected as weight for Potash alum.

g) Design of Study:

Grouping: Total three groups were made for the study. They are as follows:

- Group 'A'- Control group
- Group 'B'- Standard group
- Group 'C' - Test group

i. **Control Group:** Water sample collected from the source (well) was used without any treatment materials and methods.

ii. Standard Group: Water sample collected from the source (well) had subjected to filtration using standard filter. The filtration instrument used in this study was KENT, UF membrane water filter.

iii. Test Group: Potash alum was added to the collected water sample (well). Test group C was further divided into following groups:

Table No.1 showing grouping of potash alum

• 10 grams each for 6, 12 and 24 hours
• 25 grams each for 6, 12 and 24 hours
• 50 grams each for 6, 12 and 24 hours

h) Assessment Criteria:

- Each water sample had taken in sterile glass bottle and labeled as group A, group B and group C and kept in a normal room temperature inside the building where direct sunlight and wind would not reach the glass vessels.
- Group A- left untreated.
- Group B- subjected to standard filtration.
- For glass bottles of group C, *Sphatika* (Potash alum) was added. Later the samples had subjected for analysis separately for below mentioned parameters as prescribed by Bureau of Indian Standards 2020.

Parameters investigated are:

- **Physical Parameters:** Color, Odor, Conductivity, Salinity, Turbidity, pH, Total Dissolved Solids (TDS), Dissolved Oxygen (DO)
- **Chemical Parameters:** Total Hardness, Total Alkalinity, Calcium, Magnesium, Carbonates, Bicarbonates
- **Microbial Load Analysis:** Bacterial colony

OBSERVATIONS AND RESULTS:

Sphatika (potash alum) was the drug taken for the study. There are total three groups in the study. They are as follows:

- Group 'A'- Control group (Untreated water / Raw water)
- Group 'B' - Standard group (Filtered water)
- Group 'C' - Test group (well water added with Potash alum)

There were total 9 samples for group C. 3 each for adding of potash alum in the quantity of 10, 25 and 50 grams for the time period of 6, 12 and 24 hours respectively. After the desired time period, each sample was analyzed for physical, chemical and microbiological parameters.

Table No.2 showing physico – chemical test results of Group A (untreated water) and Group B (filtered water)

Sl No.	Parameters	Group A (Untreated water)	Group B (Filtered water)	BIS: 10500-1993 Standards
1	Colour, Hazen Units	Clear	Clear	Colourless
2	Odour	Agreeable	Agreeable	Agreeable
3	pH	6.78	5.27	6.50-8.50
4	Conductivity µS (Micro Siemens)	**122**	**46.8**	NS
5	Total Dissolved Solids	**70.9**	**29.5**	500

	(mg/L)			
6	Salinity	0.02	0.02	NS
7	Turbidity (NTU)	**3.0**	**1.0**	05
8	Dissolved Oxygen	**7.2**	**7.8**	NS
9	Calcium (mg/L)	4.0	4.0	75
10	Magnesium (mg/L)	4.86	4.86	30
11	Total Hardness (mg/L)	30.0	30.0	300
12	Total Alkalinity (mg/L)	18.0	18.0	200
13	Carbonates (mg/L)	10.8	10.8	NS
14	Bicarbonates (mg/L)	7.2	7.2	NS

Table No.3 showing physico – chemical test results of Group C (well water after 6 hrs of adding 10gms, 25gms and 50gms of potash alum)

Sl.No.	**Parameters**	**6hrs (10gms)**	**6hrs (25gms)**	**6hrs (50gms)**	**BIS: 10500-1993 Standards**
1	Colour, Hazen Units	Clear	Clear	Clear	Colourless
2	Odour	Agreeable	Agreeable	Agreeable	Agreeable
3	pH	3.62	3.52	3.43	6.50-8.50
4	Conductivity µS (Micro Siemens)	**3.78**	**5.44**	**7.47**	NS
5	Total Dissolved Solids (mg/L)	**1.99**	**3.03**	**4.09**	500
6	Salinity	0.52	0.77	1.06	NS
7	Turbidity(NTU)	**0.8**	**1.0**	**1.3**	05
8	Dissolved Oxygen	**7.3**	**7.5**	**7.9**	NS
9	Calcium (mg/L)	4.0	4.0	4.0	75
10	Magnesium (mg/L)	2.43	2.43	2.43	30
11	Total Hardness (mg/L)	-	-	-	300
12	Total Alkalinity (mg/L)	2.0	2.0	2.0	200
13	Carbonates (mg/L)	1.2	1.2	1.2	NS
14	Bicarbonates (mg/L)	0.8	0.8	0.8	NS

Table No.4 showing physico – chemical test results of Group C (well water after 12 hrs of adding 10 gms, 25 gms and 50 gms of potash alum)

Sl. No.	**Parameters**	**12hrs (10gms)**	**12hrs (25gms)**	**12hrs (50gms)**	**BIS: 10500-1993 Standards**
1	Colour, Hazen	Clear	Clear	Clear	Colorless

	Units				
2	Odour	Agreeable	Agreeable	Agreeable	Agreeable
3	pH	3.61	3.55	3.52	6.50-8.50
4	Conductivity µS (Micro Siemens)	**4.90**	**5.18**	**6.60**	NS
5	Total Dissolved Solids (mg/L)	**2.67**	**3.65**	**4.68**	500
6	Salinity	6.61	8.18	8.93	NS
7	Turbidity (NTU)	**1.5**	**1.5**	**1.6**	05
8	Dissolved Oxygen	**7.5**	**7.6**	**7.7**	NS
9	Calcium (mg/L)	4.0	8.0	8.0	75
10	Magnesium (mg/L)	2.43	4.86	4.86	30
11	Total Hardness (mg/L)	-	-	-	300
12	Total Alkalinity (mg/L)	2.0	2.0	2.0	200
13	Carbonates (mg/L)	1.2	1.2	1.2	NS
14	Bicarbonates (mg/L)	0.8	0.8	0.8	NS

Table No.5 showing physico – chemical test results of Group C (well water after24 hrs of adding 10gms, 25gms and 50gms of potash alum)

Sl. No.	**Parameters**	**24hrs (10gms)**	**24hrs (25gms)**	**24hrs (50gms)**	**BIS: 10500-1993 Standards**
1	Colour, Hazen Units	Clear	Clear	Clear	Colourless
2	Odour	Agreeable	Agreeable	Agreeable	Agreeable
3	pH	3.68	3.58	3.50	6.50-8.50
4	Conductivity µS (Micro Siemens)	**4.55**	**5.76**	**7.42**	NS
5	Total Dissolved Solids (mg/L)	**2.56**	**3.15**	**4.07**	500
6	Salinity	0.66	0.81	1.06	NS
7	Turbidity (NTU)	0.9	1.1	1.2	05
8	Dissolved Oxygen	**7.9**	**8.1**	**8.3**	NS
9	Calcium (mg/L)	4.0	4.0	4.0	75
10	Magnesium (mg/L)	2.43	2.43	2.43	30
11	Total Hardness (mg/L)	-	-	-	300
12	Total Alkalinity (mg/L)	2.0	2.0	2.0	200

13	Carbonates (mg/L)	1.2	1.2	1.2	NS
14	Bicarbonates (mg/L)	0.8	0.8	0.8	NS

Table No.6 showing microbial load analysis of Group A (untreated water) and Group B (filtered water)

Group A (Untreated water) (NOC) CFU/ml	**Group B (Filtered water)** (NOC) CFU/ml
528	375

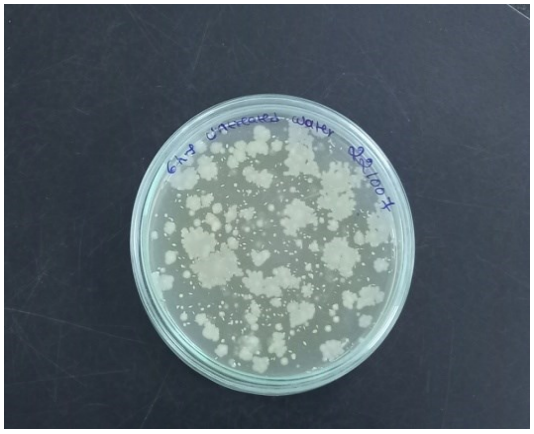

Fig. No.1 MLA of Untreated Water

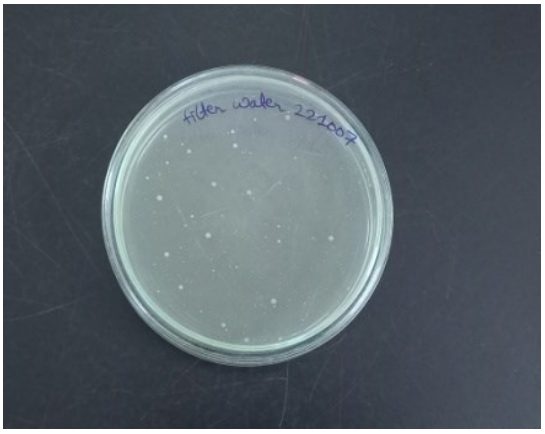

Fig. No.2 MLA after Filtration

Table No.7 showing microbial load analysis of Group C (well water after 6hrs, 12hrs and 24 hrs of adding 10gms, 25gms and 50gms of potash alum)

Sl. No.	**Incubation Time**	**10gms (NOC) CFU/ml**	**25gms (NOC) CFU/ml**	**50gms (NOC) CFU/ml**
1	6hrs	328	239	**208**
2	12hrs	14	25	**30**
3	24hrs	293	99	**77**

- CFU – Colony Forming Units
- NOC – Number of Colonies

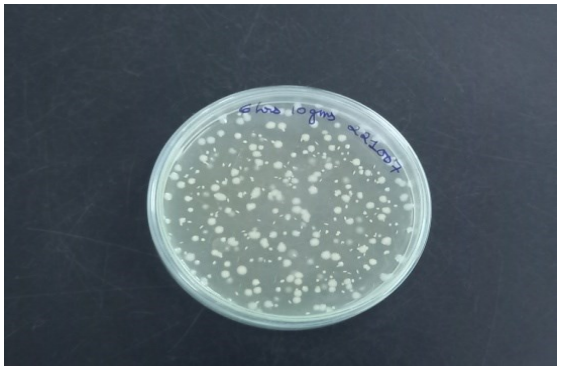

Fig. No.3 MLA after 6hrs of adding 10gms of potash alum

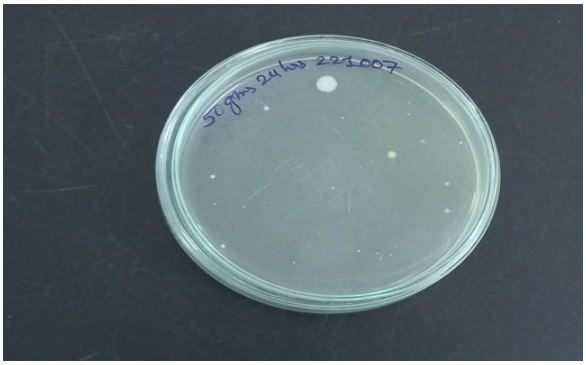

Fig. No.4 MLA after 24hrs of 50gms of potash alum

DISCUSSION:

Acharya Sushruta has mentioned seven materials which can be used for *prasadana* (purification) of *kalusha* (polluted) water; they are *Kataka, Gomeda, Shaivala moola, Visagranthi, Vastra, Mukta* and *Mani* [10]. The description about their use and procedures to be followed for purification has not been mentioned. We have to use various techniques and modifications which are available now days for their effective use. For the term *mani, Acharya Dalhana* has commented as *Sphatika*. When we go through various *Rasasastra* books we get the reference of *Sphatika* under *Uparasa* as third mineral drug i.e Potash alum as well as under *Uparatna* as Quartz. For this study potash alum was been taken. There are two types of *Sphatika* mentioned in our classics, one is *Phataki* and other is *Phullika*. Out of these two, first variety is considered fit and selected for pharmaceutical purposes [11].

Among these seven materials, *vastra* (cloth) can remove physical impurities like dirt, dust, sand and is effective for some of the pathogens only. It doesn't remove chemical impurities and mainly useful at home level only and not at community level. *Visagranthi* and *Saivalamoola* are difficult to find nowadays and moreover they are mostly useful to remove physical impurities rather than chemical. *Kataka*, *Gomeda* and *Mukta* are expensive if used for purification of water on large scale.

Sphatika (potash alum) is easily available, economical, act on physical, chemical as well as microbial parameters and mostly can be used on a large scale of water purification than other materials. Hence, it was used for the study to highlight its efficacy.

Effect of potash alum on various parameters is as follows:

Color: Pure water is colorless. Any type of color appearance in water indicates some

pollution in water. Natural water system is often colored by presence of colored organic matter, metals such as iron and manganese, or highly colored industrial wastes. The color of the well water sample was clear. After 6, 12 and 24 hrs of adding potash alum also the color remains clear. The filtered water color was also clear. There was no color change in any group.

Odor: Drinking water should be free from any kind of disagreeable odor. The odor was agreeable in all the samples. There was no change in odor after adding potash alum.

pH: The pH of untreated water was 6.78. After adding potash alum to the water samples the pH level decreased and was less than 4 making the water acidic. Potash alum is acidic in nature as it is a double salt of strong acid (H_2SO_4) and weak base ($Al(OH)_3$). Addition of alum in water samples increases the acidity as carbon dioxide gas is released, which leads to the formation of carbonic acid, thereby, increasing the acidity of water and decreasing the pH.

Conductivity: Conductivity depends on the amount of dissolved salts and other inorganic materials present in water. The conductivity of well water was found to be 122 before treatment, because of having suspended solid particles. After adding of potash alum (10, 25 and 50 gms) and after the time period of 6, 12 and 24 hrs; conductivity was observed to be decreasing. It was in between 3 – 8. This is because alum helps to coagulate the suspended solid particles like dust, pollen and other sorts of contaminants present in the water to group together to form larger size called as flocs, which further settles down [12].

Total Dissolved Solids (TDS): TDS is a measure of the dissolved combined content of all inorganic and organic substances present in water in molecular, ionized, or micro granular suspended form. TDS of water sample before treatment was 70.9. This is because of presence of some organic and inorganic substances in the well water. After adding of potash alum, the TDS was observed to be decreased significantly, because alum helps to bind the suspended solid particles present in the water to group together to form larger size which further settles down.

Salinity: Salinity is the saltiness or amount of salt dissolved in water. The salinity of both water samples before treatment and after filtration was observed as 0.02. After adding of potash alum, the salinity was observed to be increased. As the quantity of potash alum increased, the salinity increased further because potash alum is a salt of potassium and aluminium with sulfate. The salt present in it is released when mix in water samples giving rise to salinity.

Dissolved Oxygen (DO): Dissolved Oxygen is the amount of oxygen present in water. Water bodies receive oxygen from the atmosphere and from aquatic plants. Running water such as moving stream or river dissolves more oxygen than the still water of a pond or lake. Healthy water generally has dissolved oxygen concentrations above 6.5 to 8 mg/L and between 80 to 120%. The DO of water samples before treatment and after filtration were 7.2 and 7.8 respectively. After 6, 12 and 24 hours of adding of potash alum the DO was found to be increased and the level was in between 7.4 to 8.3.DO was observed to be more in highest concentrations of potash alum and at highest contact time period. If DO is increased the aquatic plants and animals will get proper oxygen which in turn release sufficient amount of oxygen in the water. And such water is fit to use. As the quantity of potash alum and contact time period increased, the DO increased further. This indicates the quality of water increased as DO is one of the most important indicator of water quality.

Turbidity: Turbidity of water is due to the presence of inorganic substances or suspended particles. The turbidity of water should not be more than 5 NTU and should ideally below 1 NTU. The turbidity of untreated water was3.0 and it decrease to 1.0 after filtration, this is due to the removal of suspended particles by the filters. The turbidity decreases after adding of potash alum and as the quantity of potash alum and contact period increases the turbidity slightly increased. Turbidity decreased after adding of potash alum, this indicates the water with less suspended particles and such water is fit to use.

Total Hardness: Water hardness is the amount of dissolved minerals in the water mainly made up of calcium and magnesium carbonates, bicarbonates and sulfates. The total hardness of the untreated as well as filter water was observed to be 30.0 mg/dl. There is no any reaction observed for total hardness after adding of potash alum to the sample. After adding of potash alum the carbonate and bicarbonate are almost negligible, thus removing the hardness of water.

Total Alkalinity: The total alkalinity was observed to be 18.0 for both untreated and filtered water sample. It decreased to 2.0 after 6, 12 and 24 hrs of adding of 10, 25 and 50 gms of potash alum. This is because after adding of potash alum there is decrease in pH, carbonate and bicarbonate. TH and Alkalinity are directly proportion to each other. Hence, Alkalinity decreases as TH decreases but the level may not be in same proportion.

Calcium and Magnesium: Dissolved calcium and magnesium are the two most common

minerals that make water hard. The degree of hardness becomes greater as the calcium and magnesium content increases. The calcium was observed to be 4.0 mg/dl for both untreated and filter water sample. There was no change in the level of calcium after adding of potash alum. The calcium concentration was within normal values for all the water samples.

Magnesium was 4.86 mg/dl for untreated water sample. It was below 5 after 6, 12 and 24 hrs of adding 10, 25 and 50 gms of potash alum. The increase in time period and quantity of potash alum did not cause the Mg level to exceed above the permissible limit. After filtration Mg level was noted to remain 4.86. Mg of the entire water sample is within the normal values as per the standards.

Carbonates and Bicarbonates: The carbonate and bicarbonate for both untreated and filtered water sample was found to be 10.8 and 7.2 respectively. While carbonate decreased to 1.2 and bicarbonate to 0.8 after 6, 12 and 24 hrs of adding of 10, 25 and 50 gms of potash alum.

Microbial load analysis : Drinking water should not contain any microorganisms or parasites. The bacterial colony count was 528 in untreated water sample. After filtration the bacterial count decreased when compared to untreated water. It highly decreased after adding of potash alum. This shows antibacterial effect of potash alum. Antibacterial effect of potash alum depends upon quantity of potash alum used as well as time period. As the quantity and time period increased the bacterial colony count decreased. Highest concentration of tried potash alum shows highest antibacterial property. Hence, more quantity can be used for more time period for better results. Moreover after adding of potash alum the water can be boiled before use to avoid unwanted micro-organisms or bacteria.

CONCLUSION:

Jala, its importance, properties, methods of its collection, guidelines for drinking water , water pollution, conservation and purification methods and various materials to be used for purification has been mentioned in Ayurveda are relevant even in present era. *Acharya Sushruta* mentioned seven materials used to purify the contaminated water which can be effectively used even today with some modifications. These are *Kataka, Gomeda, Bisagranthi, Saivalamoola, Vastra, Mukta* and *Mani. Acharya Dalhana* commented on the word *Mani* and mentioned it as *Sphatika*. As we go through various *Rasashastra* books we find that *Sphatika* means both potash alum and quartz. Potash alum was selected as a drug for the study to evaluate its efficacy in

the purification of contaminated water. Potash alum is highly used for purification of polluted water. Moreover, it is easily available, economical and procedure to be follow for purification is also simple. Based on the literary review and the experiments, the following conclusion can be drawn. 1.) The results showed significant changes in some of the parameters. 2.) Potash alum showed significant changes in some of the parameters like Turbidity, DO, TH, TA, TDS and Conductivity which indicates its ability in the purification of contaminated water. 3.) Potash alum reduces pH, Turbidity, TA, TH, TDS, Mg, Carbonate and Bicarbonate; and increases DO and Salinity. 4.) While there was no any change in Ca after adding of both potash alum. 5.) Potash alum shows antimicrobial effect. While observing the results it was found that Potash alum shows significant results. Potash alum has the properties of *Kashaya* (astringent) which helps to constrict the particles to form together. Moreover positive ions present in the potash alum helps to bind negative ions of dirt, dust and other dissolved particles which are smaller in size present in the water to form larger particles so that it sink at the bottom. Potash alum is soluble in water, thus potash alum can be used as coagulating and flocculating agent in water treatment process and can be applied prior to sedimentation and filtration process to enhance the ability of a water treatment to remove particles.

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