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Occurrence of Aluminium concentration in surface water samples from different areas of Pune city

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Abstract **- A random selection of 4 sampling locations representing the city was used for this study in which the raw and finished water samples were collected monthly for two seasons in a year and analysed for residual aluminium and pH as per APHA 3500-Al B, Ed 21st. The water samples were categorized as per the area of the city. The residual aluminium concentration in the water samples collected was observed to be above desirable limits but below permissible limits. Aluminium in drinking water samples collected from Pune city in the month of December & January found to be all below <0.03 mg/l which is desirable Aluminium in drinking water samples collected from Pune city in the month of November found to be in the range of <0.03 mg/l to 0.06 mg/l in which Katraj showing 0.05 mg/l, Kothrud <0.03 mg/l, Koregoan Park 0.06 mg/l, Hadapsar <0.03 mg/l. Limit. Linear trendline for Aluminium Vs pH for the month of September, October, November showed R^2= 0.0443, R^2= 0.1196, R^2 = 0.3531, indicating None, and medium correlation respectively. Similarly Linear trendline of the December & January showed that all aluminium values are <0.03 mg/l. So trendline cannot be ploted means that eventhough pH changes aluminium concentration in water were not found to changed. pH of drinking water samples collected from Pune city in the month of September & October found to be within minimum aluminium solubility range i.e. 6.5 to 8.5.**

Key words **- residual aluminium, pH, drinking water, health impact.**

I. INTRODUCTION

Aluminium is the third most abundant element in the earth's crust after oxygen and silicon. It occurs in nature in combination with other elements such as oxygen, silicon and fluoride. Traditionally aluminium has been considered as nontoxic to humans. However, in recent years, increased attention is being focused on possible adverse effects of aluminium on human health. Human exposure to aluminium is from its natural occurrence in the environment i.e. through food, water and air as well as from aluminium deliberately introduced into the environment by man.

Al-based coagulants such as aluminium sulphate ($Al_2(SO_4)_3$) (better known as alum) or poly aluminium chloride (PACl) are commonly used in drinking water treatment to enhance the removal of particulate, colloidal, and dissolved substances via coagulation processes. The treatment of surface water with aluminium sulphate has been in operation for over a hundred years all over the world.

The use of alum as a coagulant for water treatment often leads to higher concentrations of aluminium in the treated water than in the raw water itself. Typically, a portion of the alum added to the raw water is not removed during treatment and remains as residual aluminium in the treated water. The occurrence of aluminium in treated water has been considered for many years to be an undesirable aspect of treatment practice [1]. Barnett et al [2] reported that the use of alum as a coagulant in the treatment of drinking water increased the aluminium concentration in the finished water.

Although large portion of aluminium intake by humans comes from food, presently there is much concern on the presence of aluminium in drinking water. It is proposed that residual aluminium in drinking water after treatment with alum may be in a bioavailable form. Literature review reveals that around 90% of treated water samples collected from pilot project areas of Rajasthan, where Nalgonda technique was used at domestic level, had residual aluminium concentration beyond 0.2 mg/l. Since filtration step is not included in the domestic units, some aluminium could be in particulate form [3]. Whereas Aluminium levels in treated waters collected from few villages of Dungarpur district, Rajasthan, where pilot project studies were conducted on domestic defluoridation units, was below 0.2 mg/l in 82% samples.

There are few reports on aluminium leaching into treated waters, when indigenously manufactured activated alumina was used for defluoridation. Aluminium level of 0.58 mg/l was reported with unwashed fresh activated alumina Catad 2002 (IPCL, Thane) when defluoridation was carried out in batch operation [4]. Hence it is suggested that defluoridation should be done at pH greater than 6 to prevent leaching in water treatment plant in Pune city.

Recent interest in aluminium toxicity is due to its possible role in multiple neurological diseases such as Parkinson's disease, amyotrophic lateral sclerosis and Alzheimer disease (AD). In 1970's, many reports were published on a specific form of progressive dementia (dialysis encephalopathy) characterized by speech and behavioral changes, tremors, convulsions in chronic renal patients, who were on dialysis. This was traced to the presence of aluminium in dialysis fluids. Eliminating aluminium in dialysis fluids eliminated the dementia.

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These findings proved the neurotoxicity of aluminium. Aluminium has been linked with other forms of dementia and AD in particular. There are several reports, both for and against the hypothesis, that aluminium plays an active role in AD [5]. A number of theories have been proposed for the onset of AD, which includes genetic factors, abnormal proteins, environmental agents etc. Still complex interactions between aging and genetic predisposition and the series of events ultimately leading to the onset of AD is not known. From the available information, evidence linking aluminium and Alzheimer's disease cannot be made with any certainty.
Trond Peder Flaten [6] has studied Aluminium as a risk factor in Alzheimer's disease, with emphasis on drinking water in 2001. Aluminium (Al) is clearly a powerful neurotoxicant. Considerable evidence exists that Al may play a role in the etiology or pathogenesis of Alzheimer's disease (AD), but whether the link is causal is still open to debate.

Several epidemiological studies have been carried out to assess whether aluminium in drinking water is a risk factor. Still no conclusion has been drawn on this issue. This research is focused on study of water treatment plants in different areas of Pune city with special emphasis on Alum and PAC treatment, drinking water quality from end users of Pune city. Because of the increasing concern over the health effects associated with the aluminium and the increased bioavailability of aluminium, this study was designed to determine (1) the frequency of occurrence of aluminium and pH in the treated water and (2) the concentration of aluminium in the raw water coming to the treatment plant.

II. Survey Design

The survey used the random selection of four sampling locations geographically equally distributed. The treated water samples were collected from these four locations for a period of five months. The raw water sample was collected once from the source Khadakwasla reservoir that supplies water to the Pune city.

III. Materials And Methods

The various parameters considered to meet the project objectives were water treatment plants, Alum & PAC addition, drinking water quality, residual aluminium. The study was conducted for each parameter in three seasons namely monsoon, winter and summer. The sampling method and the analysis were done as per Standard Methods for the examination of Water and Wastewater, 21st Edition [7].

IV. Literature

A detailed study was carried out to collect baseline information related to various research work carried out on the subject, methodology used and the observations.

It included review of books, journals, websites and magazines to understand the present status of work on residual aluminium in treated water and its health impact. This step provided a general framework and basic knowledge for further research into the topic and also helped in the identification of techniques and equipments appropriate for investigation.

Site selection

Site selection was done for the study of Water Treatment Plants and drinking water quality from household end users of different end users from Pune city i.e. Katraj, Kothrud, Koregaon park and Hadapsar as shown in the Fig No. 1.

Sample collection

Secondary data was being collected from Water Treatment Plants for study of aluminium at each treatment unit and final outlet. Drinking water samples were collected from different end users of Pune city to analyze residual aluminium. Samples were collected in 1-L polyethylene containers after they had been rinsed with the water that was allowed to flow for 3 min prior to sample collection. Each container was sealed with a caplug and a screw cap. All samples were stored in the laboratory at 4^0C until analysed.

a) *Sampling points:* After the primary survey sampling points selected are as follows.

A. Katraj, B. Kothrud
C. Koregoan Park D. Hadapsar

b) *Sampling period*: Samples were collected in the month of September, October, November, December (2011) and January (2012). This pattern was chosen to detect any seasonal variations.

c) *Analysis:* Analysis of all above mentioned parameters was done in college laboratory and cross checked from MoEF recognized laboratory at Pune.

Data analysis and interpretation

Collected data was statistically and graphically analyzed. This analysis was used for interpretation for drawing out conclusion.

V. Results And Discussion

At present Pune receives its water supply from Khadakwasla reservoir about 12 km from the city through right bank canal and a closed pipeline.

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Three more dams i.e. Panshet, Warasgaon and Temghar are constructed upstream of Khadakwasla. The storage capacity of these 3 dams is 900 MM^3 whereas the present annual requirement of city is about 200 MM^3. It is estimated that 80-90% of the population is connected through Pune Municipal Council (PMC) water supply. PMC serves a water supply of 195 l/person-day (including water losses) against standard of 135 l/person-day.

There are several reports on the increase of total aluminium concentration in treated water as compared to raw water (8, 1). In the present study, in raw water sample from Khadakwasla reservoir the pH and Aluminium concentration was observed to be 7.2, 7.5, 7.2 and <0.03 mg/l for month of November, December and January respectively.

The average intake of aluminium per day by an adult may range from 5-14 mg from all exposure routes [5], which comes primarily from food. Drinking water contribution has been estimated to be ranging from 3 to 8% [5]. Contribution of air for the total aluminium exposure is generally negligible. Since there are several routes aluminium intake in our body it is difficult to correlate health impact of aluminium in drinking water.
Several studies have shown that a portion of alum added to the water is not removed and remains as residual aluminium in the treated water [8, 1, 5, 9] Aluminium salts are hydrolyzed to Al $(OH)_3$ which is practically insoluble in the pH range of 6.5 - 8.5. Solubility is enhanced under acidic (pH < 6) or alkaline pH (> 8.5) and / or in the presence of complexing agents.

The presence of aluminum in water distribution systems can be due to aluminum in the source water, aluminum leached from distribution system materials and aluminum introduced to the water from aluminum containing coagulants [10]. Other factors that may affect aluminum concentration in drinking water are temperature, pH and turbidity of the water [11].

According to Drinking Water Quality Standards (IS 10500) the desirable limit for aluminium concentration in treated water is 0.03mg/l, and permissible limit is 0.2 mg/l. The results of aluminium in drinking water samples collected from Pune city in the month of September found to be in the range of <0.03 mg/l to 0.18mg/l in which Katraj water sample Al concentration was 0.09 mg/l, Kothurd <0.03 mg/l, Koregoan park 0.11 mg/l and hadapsar 0.18mg/l. In the month of October the Al concentration in samples collected from Kothrud and Hadapsar area was found to be more than the desirable limit. In the month of November the Al concentration in samples collected from Katraj and Koregaon Park area was found to be more than the desirable limit. In the month of December and January in all water samples the Al concentration was observed to be less than desirable limit.

Graph indicates that aluminium concentration in water samples of kothrud area is below desirable Limit for 80 % of the period.

Aluminium in drinking water samples collected from Pune city in the month of October found to be in the range of <0.03 mg/l to 0.08 mg/l in which Katraj showing <0.03 mg/l, Kothrud 0.05 mg/l, Koregoan Park <0.03 mg/l, Hadapsar 0.08 mg/l.

Graph indicates that Aluminium concentration from Katraj & Koregoan Park area is below Desirable Limit. aluminium concentration from Kothrud & Hadapsar areas are within the permissible Limit.

Aluminium in drinking water samples collected from Pune city in the month of November found to be in the range of <0.03 mg/l to 0.06 mg/l in which Katraj showing 0.05 mg/l, Kothrud <0.03 mg/l, Koregoan Park 0.06 mg/l, Hadapsar <0.03 mg/l. Graph indicates that Aluminium concentration from Kothrud & Hadapsar area is below Desirable Limit. aluminium concentration from Katraj & Koregoan park areaes are within the permissible Limit.

Aluminium concentration in the month of December & January found to be all below <0.03 mg/l which is desirable Limit. It was observed from the analysis that the aluminium concentration of the raw water of Khadakwasla dam was less than 0.03mg/l, which is below the desirable Limit where as the results aluminium concentration of treated drinking water was more for some times. This indicates that there is an increase in the aluminium concentration in treated water samples because of the addition of alum and PAC in the raw water during the treatment.

Trendline for Aluminium as (Al) in different area of Pune city for different months shows:

AREA	R^2	Correlation
Katraj	0.5158	Positive medium correlation
Kothrud	0.125	Positive less correlation
Koregoan Park	0.5127	Positive medium correlation
Hadapsar	0.7398	Positive more correlation

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pH of drinking weater samples collected from Pune city in the month of September & October found to be within minimum aluminium solubility range i.e. 6.5 to 8.5. pH of drinking weater samples collected from Pune city in the month of November for Katraj & Hadapsar area are below minimum aluminium solubility range. In the month of December pH values for Kothrud area was below minimum aluminium solubility range. Month of January pH values for Kothrud area was below minimum aluminium solubility range.

Linear trendline for Aluminium Vs Ph for the month of September shows R^2 = 0.0443 indicating no correlation, October showed R^2 = 0.1196 indicating less correlation, November showed R^2 = 0.3531 indicating medium correlation, December & January shows that all aluminium values are <0.03 so trendline cannot be ploted means that eventhough pH changes aluminium concentration in water were not found to changed.

Background document for development of WHO Guidelines for Drinking-water Quality have documented aluminium. In this guideline it is mentioned that the chemistry of aluminium in water is complex, and many chemical parameters, including pH, determines which aluminium species are present in aqueous solutions. In pure water, aluminium has a minimum solubility in the ph range 5.5–6.0; concentrations of total dissolved aluminium increase at higher and lower pH values. Aluminium levels in drinking-water vary according to the levels found in the source water and whether aluminium coagulants are used during water treatment.

In this research drinking water quality from end users of Pune city reveals that in most of the water samples the Al concentration is above desirable limit but below permissible limit. This means that the residual Al is present in the treated water samples of Pune city.

VI. CONCLUSIONS

The raw and treated water samples collected from Pune city contain Aluminium concentration within the desirable and permissible limits. Still it is evident that Al is added into the water during treatment of raw water. Also the treated water sample contains more Al concentration than the raw water sample. From this again it is clear that the Al is added into the water during its treatment. Utmost care should be taken during the addition of coagulant alum/ PAC into the raw water to avoid the effect of Al on human health.

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Fig No.1: Sampling locations in Pune city

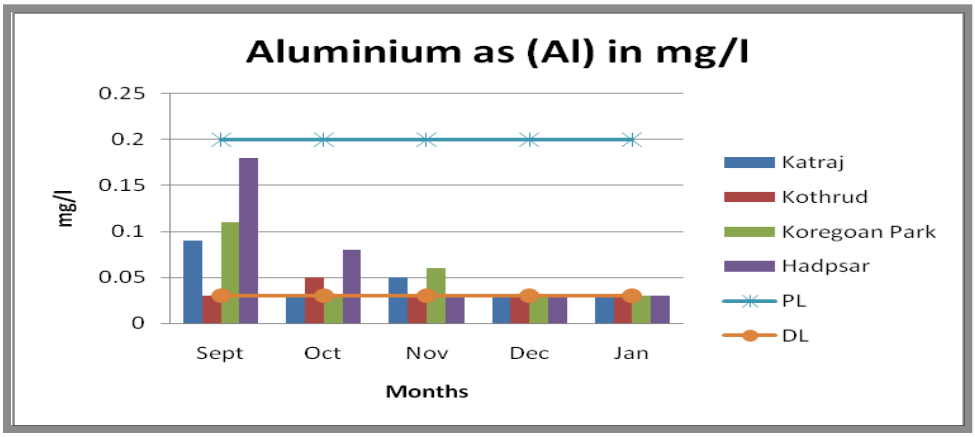

Fig No. 2: Aluminium Concentration

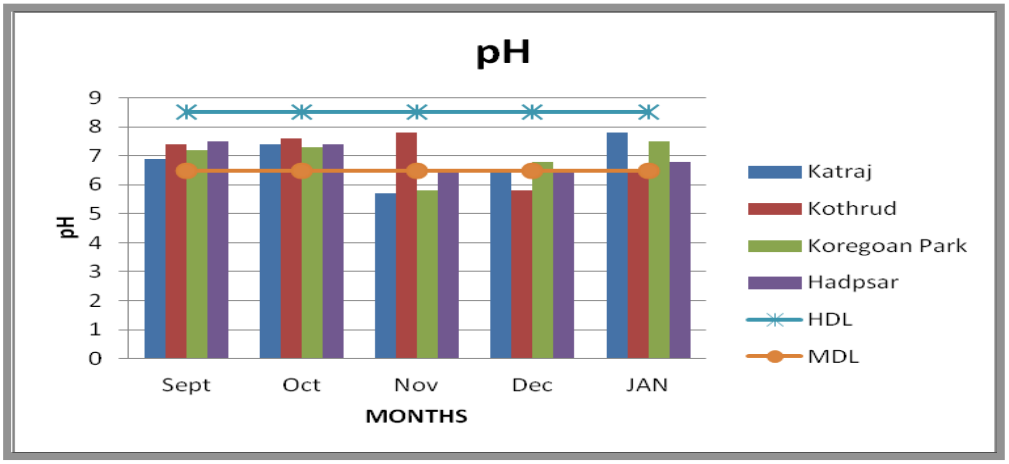

Fig No. 3: pH of water samples