

## Epidemiological survey of ground water fluoride toxicity in 6 to 10 year old children of Prayagraj

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**Abstract :** The deterioration in quality of water influences the entire ecosystem and may cause health Problems. During the last many years the ground water draft has increased enormously and the natural recharge has been reduced to a large extent and a fall by 2 m water table during summer in city area. has been reported, which might have been a reason for the deterioration of Underground water quality. The Prayagraj district lies between 24°47' and 25.47'N and 81°09' and 81°21'E and spreads in an area of 5246sq km<sup>1</sup> with an average of 934mm of annual rainfall, 90% of which occurs from June to September paving the way for available water for deep percolations into the ground aquifer. A decade long study revealed a slow increase in the concentration of fluoride in underground water in the study area of (latitude 25° 27' to 25°45' and longitude. 81°24' to 81°50') in Prayagraj city situated in the southern part of Uttar Pradesh India. The survey conducted on 960 children of the age group of 6-10 years from economically weaker section of the society revealed that 230 children were found to be affected by fluoride toxicity.

**(Keywords :** Fluoride, Water Quality, Increasing Trend of Fluoride, Fluoride toxicity).

### Introduction

River Yamuna and Ganga traverses in the south and north of the Prayagraj city respectively and meets at Sangam. The trans Yamuna region mainly Shankergarh, Koraon, Meja and Manda has denudational hills

formation along with a patch of older alluvial plains along with the river side whereas, the older alluvial plain forms the trans Ganga Region<sup>1</sup>. In the present scenario the ground water in the district is being extracted the most and the ground water table is affected by drainage and the quality of ground water depends dominantly on geological processes and lithological factors, climate change, environmentally unfriendly agricultural activities, poor sanitation practices and ill conceived land fill management.<sup>2</sup>

The average water table at Prayagraj District remains around:-<sup>1</sup>

Season and area	Depth of water level
Pre-Monsoon Trans Yamuna Region	3.02 to 15.0 mbgl
Pre-Monsoon Trans Ganga Region	6.0 to 7.0 mbgl
Post-Monsoon Trans Yamuna Region	5.0 to 6.0 mbgl
Post-Monsoon Trans Ganga Region	1.45 to 13.0 mbgl

The surface of earth acts as a store house of all the toxic and non-toxic substances accumulated on it due to anthropogenic activities. Nature is the best manager to take care of its self and to heal its wounds sooner or later. Hydrological cycle is a phenomenon through which nature provides enormous amount of fresh and clean

water for the sustenance of life on earth and to wash away many pollutants from the surface of earth. It is the surface landmass that bears the brunt of the anthropogenic activities and from where some of the unwanted substances flow in the environment including air and surface as well as ground water bodies.

The concentrations of some heavy metals in the ground water is increasing day by day and are spreading even in those areas where they were absent earlier. Although the extensive use of ground water for cultivation has promoted a high crop yield.<sup>3</sup> and the State Government has been providing financial aid from time to time for the installation of shallow tube wells for irrigation, drinking and domestic uses but at the same time this has resulted in the increase of Fe, F and As contamination in the ground water.<sup>4-6</sup> The present study is related to the prevalence of fluoride toxicity at Prayagraj city.

Fluorine (atomic No.9, electronic configuration  $1S^2, 2s^2 2P^6$ ), the most electro-negative and highly reactive diatomic, pale yellow-green gas was discovered on June 26, 1886 by Professor Henry Moissan. In common usage fluorine is used to denote collectively the element in all of its forms, for example - free ironized or ionizable form. Fluoride has geological origin and is widely distributed in varying amounts in sea water, drinking surface and underground water, soil, dust and mineral deposits in the form of fluorspar, cryolite and fluorapatite etc. and also in food stuffs like vegetables, fruits and grains. The principal source of fluoride to human being and animals are drinking water, vegetation grown on fluorotic soils and water, certain edible marine animals, dust in air creeping due to certain industrial activities. However drinking water is the main source of chronic fluoride intoxication to man and animals<sup>7</sup>

The fluoride is distributed throughout the world and the natural waters contain fluoride from 0 ppm to as high as 2800 ppm. In India some

districts of Andhra Pradesh (undivided), Gujarat, Rajasthan, Himachal Pradesh, Uttar Pradesh, Chhattisgarh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab and Tamil Nadu contain fluoride in ground water.<sup>8-10</sup>

Fluoride finds greater affinity for calcium Phosphate, therefore approximately 99% of the body burden of fluoride is present in bone. Ingestion of fluoride in appropriate concentration is essential for proper mineralization and development of bones and teeth, prevents osteoporosis and dental caries. The intake of drinking water with scanty amount of fluoride is detrimental to tooth health whereas intake of fluoride in excess causes fluorosis, affects liver, kidney and reproductory organs and also causes teratogenic effect.<sup>11-14</sup> The excess of fluoride combines with calcium to form Calcium Fluorapatite and then the teeth becomes hypo-plastic with brown discoloration called as dental fluorosis.<sup>15</sup>

The effect of different concentrations of fluoride in drinking water is as follows:-<sup>16</sup>

Fluoride Concentration in mg/L	Effect on Human Health
Less than 0.5	Dental Caries
0.5 to 1.5	Prevents tooth decay and promotes dental health
1.5 to 4.0	Dental Fluorosis
4.0 to 10.0	Skeletal Fluorosis (Pain in neck bone and back)/ Crippling Fluorosis

The chronic toxicity of fluoride in man was first reported by Eager in 1901<sup>17</sup> Endemic Skeletal fluorosis was first described in India by Shortt et. al. 1937<sup>18</sup> among the residents of Nellore District in Tamil Nadu. Accumulation of fluoride in the soft tissues of brain affects enzymes responsible to lower the concentration of free radicals and its associated metabolism, membrane transport and synaptic transmission<sup>19-</sup>

<sup>20</sup> causes toxic neuronal injury leading to behavioral deficit and reduced mental work capacity in children of the age group of up to 12 to 13 years who grow up in fluoride endemic area<sup>21</sup> and in workers who had chronic exposure to industrial fluoride<sup>22</sup> may develop permanent skeletal deformity and damage to spinal cord. Fluoride has a potential to increase the skeletal mass and to alter the skeletal architecture. Skeletal fluorosis in the spine, pelvic and forearm is well known in human beings.<sup>23</sup> Fluoride stimulates the parathyroid gland which results in bone resorption and skeletal transformation.<sup>24</sup> The studies on some mammals like rat, rabbit and goat have shown the toxic effect on soft tissues like muscles<sup>25-26</sup>, collagen, liver<sup>27-33</sup>, kidney<sup>34-37</sup>, gastrointestinal tract<sup>38-41</sup>, and reproductive organs (like the production of nonfunctional sperms with structural defect in spermatid and spermatozoa leading to infertility)<sup>42,43,44</sup> Embryo toxicity might be due to oxidative stress mediating factors in pathogenicity in the brain<sup>45</sup> and liver<sup>46</sup>

Exposure of female workers to fluoride causes abnormal menstruation, increases the frequency of miscarriage and pregnancy complications, decreased birth rates<sup>47</sup>. Fluoride hardens and calcifies the blood vessels thus narrowing the passage of blood flow hampering the growth of fetus leading to repeated abortions or still birth<sup>48</sup>. Men women and children affected by fluoride are often exposed to multiple sources of fluoride such as food, water, air and excessive use of toothpaste. However drinking water is the most significant source of fluoride. At some places the indoor burning of fluoride rich coal also serves as an important source of fluoride. Fluoride in water is mostly of geogenic in origin. Intake of 14 mg fluoride per/day with water and food stuffs is a primary causative factor for the endemic skeletal fluorosis, which is a major public health problem and bears social economic impact affecting millions of people in our country<sup>61</sup>. Elevated Fluoride Consumption may affect Pineal Gland and lead to Cancer (Lime back 2001). The dental, skeletal and non-skeletal fluorosis are

becoming more and more prevalent and more than 62 million people including more than 6 million children below the age of 14 years across 20 states in India suffer from it.<sup>62</sup> The dental fluorosis can be checked by well-defined and widely used indexes - the deans index<sup>63</sup> and TF index<sup>64</sup>.

On the contrary to dental fluorosis skeletal and non-skeletal fluorosis are very difficult to be diagnosed and almost impossible to quantify.<sup>65</sup> E Dahi elaborates on the three physical test proposed by Susheela and Bhatnagar as indicators of non-dental fluorosis: (1) Bending the body to touch the floor (2) Bending the neck to touch the chest with chin and (3) Stretching the hands and folding the arms to touch the back of the head.<sup>66</sup> Further studies revealed that the three tests are of no use and can be directly misleading and give false indications

#### **Amelioration**

Administration of Vitamin D<sup>49</sup> and Vitamin C<sup>50</sup> significantly lowers the effect of fluoride induced reduction in the body weight and has been found to be helpful in checking the incidence of skeletal and visceral abnormalities. Significant recovery on treatment with Vitamins C+D+E maybe attributed to the free radical scavenging actions of these vitamins. The antidotal effect of vitamin E is because Alpha tocopherol has the capability of donating hydrogen which prevents oxidative damage caused by fluoride due to increased formation of peroxides, free radicals and reactive oxygen species<sup>51</sup> Another study<sup>52</sup> has revealed the treatments with vitamin C and D together with calcium produced a significant improvement in skeletal, clinical fluorosis and biochemical parameters in children drinking water containing 4.5 ppm fluoride. Vitamin D stimulates the intestinal absorption of calcium and phosphate raising its concentration in plasma and helps in maintaining the serum calcium and phosphorus concentration and thus supporting the cellular process<sup>53</sup>. A combination of vitamins C,D and E

with calcium has been found to be more efficient in amelioration possibly due to synergistic action of all of them. Withdrawal of fluoride (i.e. Removal of fluoride from water) and administration of calcium and vitamins C, D & E has ameliorative effects on fluoride toxicity<sup>54-59</sup>

The biological response and severity of fluoride toxicity mainly depends on the concentration of fluoride in drinking water, the daily intake of fluoride, the continuity and the duration of exposure and nutritional status in respect to the intake of calcium and Vitamin D. The composition of food in respect to Ca, Mg, P and Al, age, sex, occupation, growth of the bone are also the factors, which influence the toxic effects of fluoride. The toxic effects are more severe in children with growing bones and also there is no conclusive evidence proving that fluoride is an essential nutrient for human health<sup>60</sup>.

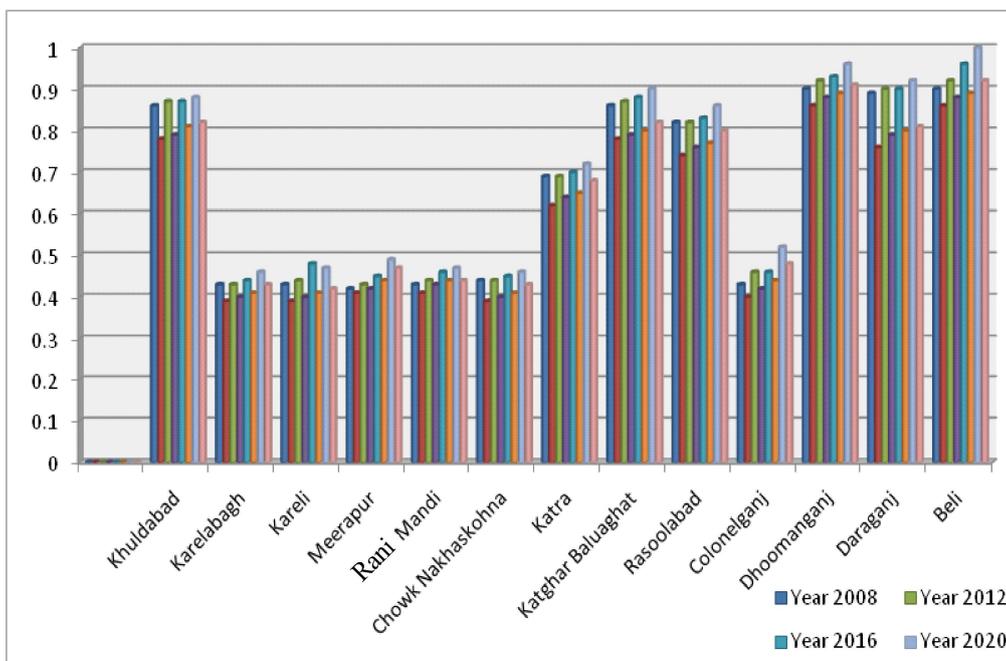
**Water Quality in Prayagraj City with reference to Fluoride contamination in underground water and its health effects**

The deterioration of environment and quality of water influence the entire ecosystem and may cause health problems. During the past many years the ground water draft has increased enormously and the natural recharge has been reduced to a large extent and a number of water bodies have vanished which resulted in the fall of water table in the city area to the extent of up to 2 meters during summer. The over exploitation and consequent recharge of the underground aquifer i.e fall and rise of underground water table may bring changes in the quality of water due to dissolution of more and more minerals. Our study was limited to test the quality of water with special reference to fluoride contamination of ground water and its health effect. The area chosen for study is Prayagraj city which belongs to the latitude of 25° 27' to 25°45' and longitude of 81°24' to 81°50'. The following is the result of analysis of water samples (by the method of APHA 2014) of hand pumps of different areas for the presence of fluoride is given as follows in Table-1

**Table-1**  
**Fluoride concentration in ppm in the water samples of hand pump in different areas of Prayagraj during Pre-monsoon and Post-monsoon period**

Areas	Year 2008		Year 2012		Year 2016		Year 2020	
	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
Khuldabad	0.86	0.78	0.87	0.79	0.87	0.81	0.88	0.82
Karelabagh	0.43	0.39	0.43	0.40	0.44	0.41	0.46	0.43
Kareli	0.43	0.39	0.44	0.40	0.48	0.41	0.47	0.42
Meerapur	0.42	0.41	0.43	0.42	0.45	0.44	0.49	0.47
Rani Mandi	0.43	0.41	0.44	0.43	0.46	0.44	0.47	0.44
Chowk								
Nakhaskohna	0.44	0.39	0.44	0.40	0.45	0.41	0.46	0.43
Katra	0.69	0.62	0.69	0.64	0.70	0.65	0.72	0.68
Katghar								
Baluaghat	0.86	0.78	0.87	0.79	0.88	0.80	0.90	0.82
Rasoolabad	0.82	0.74	0.82	0.76	0.83	0.77	0.86	0.80
Colonelganj	0.43	0.40	0.46	0.42	0.46	0.44	0.52	0.48
Dhoomanganj	0.90	0.86	0.92	0.88	0.93	0.89	0.96	0.91
Daraganj	0.89	0.76	0.90	0.79	0.90	0.80	0.92	0.81
Beli	0.90	0.86	0.92	0.88	0.96	0.89	1.0	0.92

The table- 1 has been depicted by the bar diagram below:-



A continuous increase in the concentration of fluoride in underground water has been recorded from the year 2008 to 2020 at a regular interval of four years. The results show a disturbance in the upper strata whereas the water samples from tube wells showed the presence of negligible amount of fluoride. This might be due to the fact that river flows on the three sides of the city (Figure1) and the lower strata gets recharged by river water through paleochannels.

**Survey of prevalence of fluorosis among the children from economically weaker section of the society.**

During the period from 2008 to 2020 we surveyed 960 children of the age group of 6 to 10 years from the economically weaker section of the society and collected the following data based on the study of their dental problems (Table 2).

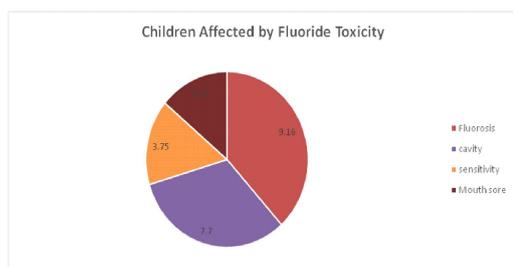


**Figure 1 Google Map of City showing the position of Rivers**

**Table - 2 Children found affected by fluoride toxicity.**

Sr. No.	Dental Problems	Number of children infested	Percentage out of 960
1	Fluorosis	88	9.16
2	Cavity	74	7.7
3	Sensitivity	36	3.75
4	Mouth Sore	32	3.33

The above data revealed that 230 children were found affected by fluoride toxicity out of 960 children examined



### Precautions and Remedial Measures

Precaution has to be taken if the underground water from upper strata (i.e hand pumps) along with fluoride rich food stuffs e.g. Black tea / Lemon tea, Black and rock salt (in food preparations), habit forming Churan and

Hajmola etc are eaten or by using fluoridated tooth paste, the children susceptible to acquire diseases may also get infested with skeletal or non-skeletal fluorosis. The safe limit of fluoride consumption in Children is from 0.3 to 0.5 ppm and in adults it is from 1.0 ppm (BIS) to 1.5 ppm (WHO).

The Following remedial measures were suggested to children. Diet rich in essential and micronutrients like Zinc, Copper, Magnesium, Calcium, Vitamin C, D and E through fruits and vegetables should be taken.

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