Seasonal Trends of $PM_{2.5}$ in heavy traffic zones in Durg – Bhilai region of Chhattisgarh

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Abstract

Road traffics have significant impact on air quality particularly in densely urbanized and populated areas where vehicular emission is a major source of particulate matter (1). About 96 samples of $PM_{2.5}$, across the two seasons of summer and winter 2015-2016, were collected on quartz fibre filters in different traffic areas (Supela square, Patel square, and Mini-mata square) monitoring sites of Durg District, Chhattisgarh, India, in the duration to determine their concentration levels and to investigate comparison with those reported in National ambient air quality standards (NAAQS). The mass concentrations of $PM_{2.5}$ have been observed higher than the annual standard stipulated by CPCB called National Ambient Air Quality Standard (NAAQS) for fine (40 µg m^{-3}) (2) and by the United State Environmental Protection Agency (USEPA) ($PM_{2.5}$ = 15 µg m^{-3}). The mass concentrations of $PM_{2.5}$ has shown following trend in summer: Supela square (278.78 ± 94.90 µg/m^3) >Patel square (250.73± 101.09 µg/m^3) >Mini-mata Square (225.78 ± 64.75 µg/m^3). The mass concentrations of $PM_{2.5}$ trend obtained in winter was: Mini-mata Square (570.30 ± 72.56 µg/m^3)>Supela square (556.23 ± 90.42 µg/m^3) >Patel square (489.22 ± 117.68 µg/m^3).

1. Introduction:

Air quality in developing countries like India has reached alarmingly low level. Most cities have exceeded the National Ambient Air Quality (NAAQ) standards. Particulate matter ($PM_{2.5}$) is a majorconcern in Indian cities and 60 out of 62 metropolitan cities haveexceeded World Health Organization (WHO) standards (24-h ambientair quality standards). Air pollution has become one of the leadingcauses of death in India.Urban India depicts apicture of metamorphosis. Most cities are growing rapidly.Moreover, urban populations are growing at a faster ratethan the national averageSurface transportation in the Indian subcontinent is a huge source of local air pollution and therefore contributes to local level air quality deterioration, human health risks and global scale climate change [1]. Traffic statistics in India show that the number of motor vehicles has increased from 50 million in 2009 to 150 million in 2012. The number of registered vehicles in the country grew at a Compound Annual Growth Rate (CAGR) of 9.9% between 2001 and 2011 [2]. Several studies have shown that vehicular emissions are a major culprit for the air quality degradation in Indian cities [3,4,5,6,7,8].Urban air pollution problem directly related to exhaust and non-exhaust motor vehicle emissions of particulate matter and other hazards pollutants. Because of sources of these emissions the public health implications are substantial. Therefore, better understanding of traffic emissions and associated environmental impacts in India is needed. Current article presents an overview of urban traffic emissions and associated impacts in the Indian context [3,4].

2. Material and methods:

2.1 Study design

Study design has been adapted for $PM_{2.5}$ monitoring at three different traffic zones (Supela square, Patel square, and Mini-mata square) during summer and winter 2015 – 2016, inDurg-Bhilai region, Chhattisgarh, India. (Fig. 1) Durg District is a populous District of Chhattisgarh. It occupies the south-western part of the Chhattisgarh plain and possesses belts of hilly country in the south, southwest and northwest, bestowed with mineral resources and forests. Durg generally has a dry tropical weather which is moderate but on a warmer side in summer season. The peak temperatures are usually reached in May/June and can be as high as 45^{o}C. The onset of monsoon is usually from July and the season extends up to September, with monsoon peaking during July and August. Maximum, Average & Minimum Rain fall Of District Durg are 1477.2 mm, 1071.16 mm and 781.5 mm per year respectively.

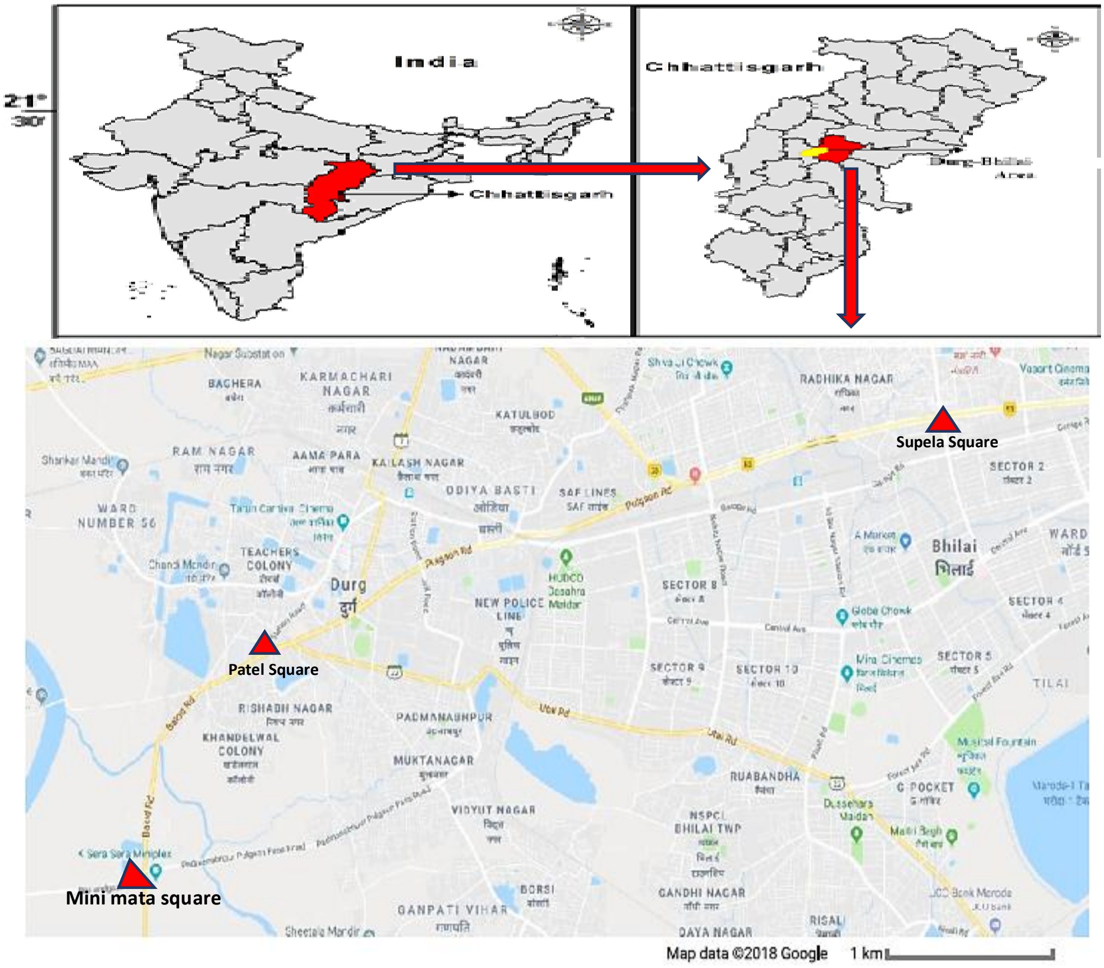

Fig 1 : Map of Durg district showing sampling site .

2.2 Sampling method

Low volume samplers (MiniVol, Air Metrics, USA) were used in sampling sites to collect integrated 24-h $PM_{2.5}$ sample between two seasons summer and winter. A total 96 (In summer Supela square n = 18, Patel square n= 15, Mini mata square n= 15 and Supela square n = 18, Patel square n= 15, Mini mata square n= 15samples were collected during this period. Sample were installed in all sampling site at a height of 5 feet from the ground level to measure exposure level of $PM_{2.5}$ concentrations.

Sample were collected on pre-fired quartz fibre filters (QFF) with the flow rate of 5 L per minute. The exposed filters were stored in filter cassettes at 4^0C until chemical analysis.

2.3 Quality Control

The quality control in monitoring was made to check the daily flow rate calculation to make sure that the fluctuation in flow rate was within range. The impactor was used to classify particulate depending on their size of less than 2.5µm. Periodic cleaning of the sampler was done to make the sampler dust free so that the dust on the sampler may not be counted with the mass concentration of the sample. Chow et al., (1998) had suggested filter change in the impactor after 72 h of the sampling, but in this study filter was changed after 48 h[9].

2.4 Gravimetric and Chemical analysis

Before exposure, the quartz fibre filter paper was preheated at 450 ^{0}C for 2 h to eliminate the organic species. Before weighing the filters were desiccated at 27±1 ^{0}C and relative humidity 35±1% in humidity-controlled room for 24h. Filter paper were weighed three times using a TB-2150 microbalance (Denver Instrument, Germany, precision of ± 10 µg). The mass concentration of $PM_{2.5}$ was ascertained gravimetrically by weighing the full filter papers before and after the sampling.

3. Results and Discussion:

3.1 Concentration of $PM_{2.5}$

The mass concentrations of $PM_{2.5}$ has shown (table 1, Fig. 2) following trend in summer: Supela square (278.78 ± 94.90µg/m^3) >Patel square (250.73 ± 101.59µg/m^3) >Mini mata square (225.78 ± 64.54µg/m^3). The mass concentrations of $PM_{2.5}$ trend obtained in winter was: Mini mata square (570.30 ± 72.86 µg/m^3)>Supela square (556.23 ± 90.42µg/m^3)>Patel square (489.12± 117.68 µg/m^3). It is higher than the annual standard stipulated by CPCB called national ambient air quality standard (NAAQS) for fine 40 µg m^{-3} and by the United State Environmental Protection Agency (USEPA) ($PM_{2.5}$ = 15 µg m^{-3}). Highest $PM_{2.5}$ concentrations were observed in winter in all locations has been ascertained due to low wind speed, low mixing height, as well as low temperature. During stable and cold conditions, the particulates could not disperse and accumulation of particulates take place.

Table 1. Seasonal Concentration (µg m^{-3}) of $PM_{2.5}$

	Concentration (µg m^{-3}) of $PM_{2.5}$	
Sampling Sites	Winter	summer
Traffic zone		
Supela square	556.23 ± 90.42	278.78 ± 94.90
Patel Square	489.12 ± 117.68	250.73 ± 101.59
Mini mata square	570.30 ± 72.86	225.78 ± 64.45

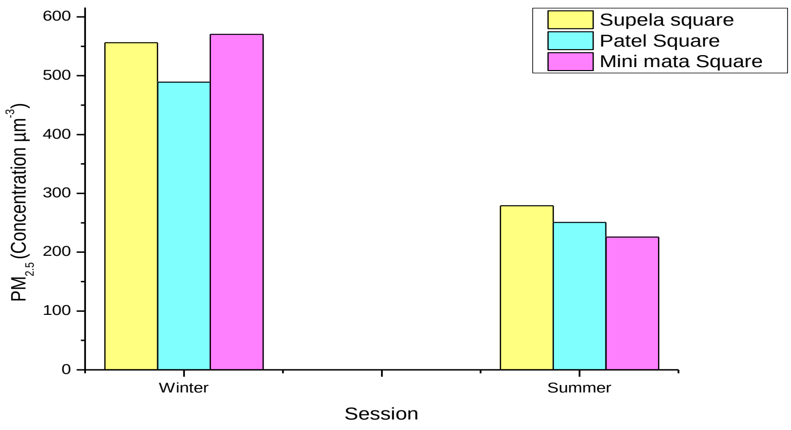

Fig 2 : Concentration of $PM_{2.5}$ in Winter and Summer session

4. Conclusion:

This study reveals that air pollution at traffic intersections in Durg Bhilai region is critical. Even with the introduction of advanced emissions control technology, motor vehicles remain the dominant sources of air pollution. Based upon the sampling in different traffic zone, the result obtained suggested that the concentration of fine particulate is higher in all traffic zone as compare with AQG (Air Quality Guidelines) given by WHO for $PM_{2.5}$. Addressing this problem requires a better understanding of the source and cause of emissions and an effective means of addressing in-use emissions. The uncontrolled growth of the vehicle fleet following the improvement to the road system represents the worst outcome, in terms of air quality.

5. Acknowledgement:

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High Fluoride Concentration in Ground Water in Parts of Chhattisgarh – A Review

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Abstract

Groundwater quality problems have emerged in many geographical areas due to natural environmental processes and human intervention in the geosystems. Among the water quality parameters, fluoride ion exhibits unique properties as its concentration in optimum dose in drinking water is advantageous to health and if the concentration exceeds the limit, this affects the health. High fluoride concentration in the ground water and surface water in many parts of the world is a cause of great concern. India has acute public-health problems induced by utilization of groundwater as a source of drinking water. The main source of fluoride in ground water is fluoride-bearing rocks This paper will focus on fluoride concentration and its relationship to water-quality parameters and its impacts on humans through groundwater resources in different parts of Chhattisgarh.

Keywords*: Groundwater, Geosystem, Contamination, fluoride-bearing rocks*

1.Introduction

Fluoride in small concentration (upto 0.6 mg/L) in drining water is essential for good dental health but higher concentration of fluoride (more than 1.5 mg/L) causes dental and skeletal fluorosis [1, 2]. High fluoride concentration in the ground water in many parts of the world is a cause of great concern. Ground water is considered to be in purest form, but as it comes in contact with rocks due to dissolution of minerals it becomes polluted. The main source of fluoride in ground water is fluoride-bearing rocks such as fluorspar, fluorite, cryolite, fluorapatite and hydroxylapatite [3,4]. Also the content in ground water is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, pH, temperature, concentrations of calcium and bicarbonate ions in water [1,5,6].

It is estimated that around 200 million people among from 25 nations the world over are under the dreadful fate of fluorosis. The higher concentration of fluoride in ground water associated with igneous & metaphoric rocks such as granites and gneisses have been reported from China, India, Pakistan [7,8,9]. In Indian the disease is endemic in about 275 districts of 20 states [10]. The most seriously affected areas are Andhra Pradesh, Punjab, Haryana, Rajasthan, Gujrat, Tamilnadu & Utter Pradesh [11,12,13,14].

Chhattisgarh is a newly formed state of India (1st November 2000) after partinoing Madhaya Pradesh. A resource-rich state, it is a source of electricity and steel for the country, accounting for 15% of the total steel produced [15]. Chhattisgarh is one of the fastest-developing states in India [16]. Fluoride is a new threat determined for the population of Chhattisgarh. In Chhattisgarh endemic pockets of fluoride were found in Durg , Bastar, Kanker, Surguja, Surajpur, Balrampur, Balod and Korba districts [10]. This paper will focus on high fluoride concentration in some parts of Chhattisgarh.

2.Source of Fluoride contamination

2.1 Geogenic source

Fluoride in ground water is mainly a geogenic contamination, when ground water comes in contact with rocks containing fluoride bearing minerals, then dissolution of these minerals increases fluoride concentration in ground water. The ultimate concentration of fluoride in groundwater largely depends on reaction times with aquifer minerals. High fluoride concentrations can be built up in groundwaters which have long residence times in the aquifers. Such groundwaters are usually associated with deep aquifer systems and a slow groundwater movement [5]. The common fluorine bearing mineral and their formula is shown in Table 1.

Table 1: Chemical composition of fluoride bearing minerals

Name of mineral	**Chemical Formula**
Topaz	$Al_2(F,OH)_2SiO_4$
Fluoroapatite	$Ca_{10}(PO_4)_6F_2$
Fluorite	CaF_{2s}
Villiaumite	NaF
Sellaite	MgF_2
Cryolite	Na_3AlF_6
Wagnerite	Mg_2PO_4F
Mica	$AB_{2-3}(X,Si)_4O_{10}(O,F,OH)_2$
Vesuvianite	Ca,Mg Silicates with F
Tourmaline	Borosilicate with F

2.2 Chemical compositon of ground water

High-fluoride groundwaters are mainly associated with a sodium-bicarbonate water type and relatively low calcium and magnesium concentrations. Such water types usually have high pH values. Information on chemical composition of groundwater can be used as an (proxy) indicator of potential fluoride problems [1].

If calcium is present in higher concentration it is most effective in reducing the fluoride concentration. A strong negative Correlation has been observed between Ca and F in the ground waters that contain Ca in excess of that required for the solubility of fluoride minerals.

The positive correlation between F- and Na+ & silica indicates the source of F- in ground water to be from weathering of silicate minerals. The positive correlation between F and Na+ indicates dissolution of feldspar from feldspathic sandstones.

Since the increase in Na+ concentration increases the F- bearing minerals, the geochemical process leading to increase in conc. of Na^{+} & decrease in Ca^{2+} plays an important role in F^{-} enrichment in ground water.

2.3 Anthrapogenig activities

Many industries such as aluminum industry, steel production plants, superphosphate plants, ceramic factories, coal-burning power plants, brickworks, glassworks, and oil refineries discharge effluents containing fluoride in them to water bodies.

3. Impact of fluoride on health

3.1 Dental fluorosis

Dental fluorosis is minerlization of tooth enamel caused by ingestion of high concentration of fluoride during enamel formation [17,18]. The severity of the condition is dependent on the dose, duration, and age of the individual during the exposure. There are three stages of dental fluorosis. In the "very mild" stage small, opaque, white areas scattered irregularly over the tooth, then in the "mild" form mottled patches developes on half of the surface area of the teeth. But in moderate form, entire teeth get mottled and teeth may be ground down and brown stains occur on the teeth. Severe fluorosis is characterized by brown discoloration and discrete or confluent pitting; brown stains are widespread and teeth often present a corroded-looking appearance [17]. People with fluorosis are relatively resistant to dental caries [19]. Dental fluorosis occurs due to conversion of hydroxyapatite into fluorohydroxyapatite.

3.2 Skeletal fluorosis

Skeletal fluorosis is a bone disease. It happens due to excessive accumulation of fluoride in the bones. Presence of high concentration of fluoride in the body causes harding of bones and they become less elastic Therefore such bones are more keen to fracture. Other symptoms include thickening of the bones and accumulation of fluoride in bone tissues, which makes the joint mobility impossible. Ligaments and cartilage can become ossified [20]. In advanced stages, skeletal fluorosis causes painful damage to bones and joints. Severity of the desease can lead to neurological defects or compression of spinal cord.

3.3 Other diseases

High fluoride concentration in body causes gastrointestinal problems, urinary tract malfunctioning, nausea, abdominal pain, tingling sensation in fingers and toes, reduced immunity, repeated abortions or still births, male sterility, etc [21]and also affect the functioning of kidneys [22].

Several cases of fluorosis in human beings and animals are also reported in different parts of Chhattisgarh (Table 2).

Table 2: Fluorosis reported in parts of Chhattisgarh

Study area	**Fluorosis reported**	**Reference**
Raigarh	Dental & skeletal fluorosis in humans	[23]
Rajnandgaon	Skin, dental and skeleton fluorosis in humans and domestic animals	[24]
Balod	Skeletal fluorosis in humans	[25]
Surajpur	fluorosis in humans	[26]
Kanker	Dental & skeletal fluorosis in humans	[10]
Durg	Dental & skeletal fluorosis in livestock population	[27]

4. Fluoride in parts of Chhattisgarh

In this paper fluoride contaminated areas of six district of chhattisgarh were considered i.e. Raigarh, Rajnandgaon, Kanker, Surajpur, balod and Durg. Description of these areas are given in breif in Table 3.

Table 3: Description of parts of Chhattisgarh with high fluoride concentration

Study area	Location Description	Geology	Reference
Tamnar block, Raigarh	lat. 22°05′N and 22°15′N, and long. 83°20′E and 83°30′E, covering about 240 sq. km area.	The area is covered by the rocks of Barakar, Barren measure, Raniganj and Kamthi formations of Gondwana Supergroup, consisting of a thick sequence of sandstones, shales, carbonaceous shales, clays and coal seams.	[23]
Kourikasa in Ambagarh Chouki block , Rajnandgaon	$20^0$43’9’’N and $80^0$44’7’’E	Rocky basement covered by alluvium, colluvium, and soil. Tube wells tap groundwater in the fracture system in bedrock.	[24]
Dongargarh, RJN	21^0 06’N 81^0 02’ E	-	[4]
Balod	area of the district is ≈4000 km^2 with population of 1.3 million	-	[25]
Surajpur	area of 16034.4 Sq.kms with 54 percent of tribal population	Archean, Gondwanas, Lametas and Deccan trap group of rocks overlain by sub Recent to Recent alluvial sediments.	[26]
Domarpani village is located in a Narharpur block Kanker	Domarpani village is located in a Narharpur block of Kanker district with population 1593	-	[10]
Durg	Bemetara, Saja, Navagarh, Berla, Patan, Dhamdha		[27]

5. Methods of analysis of fluoride in water samples

Fluoride in water samples is generally analysed by colorimetric method or by potentiometric ion selective method (ISE). ISE method gives accurate result but euipment is costly whereas colorimetric method is less time consuming and cost effective [28]. Fluoride Ion Selective Electrode consists of a single crystal of lanthanum fluoride as the membrane. Only fluoride ions are mobile to this membrane. When it comes in contact with fluoride solution, a potential develops across the membrane which is directly proportional to the fluoride ions in the solution. In SPADNS method fluoride reacts with certain zirconium dyes to form a colourless complex and another dye. The dye becomes progressively lighter as fluoride concentration increases. Absorbance is measured at 570 nm and fluoride values for the samples were determined by ploting calibration curves. Whereas in case of alazarine complex method fluoride decolorizes the zirconium alazarine complex and decolourization is proportional to fluoride concentration in water. Description of these methods are given in Table 4.

Table 4 : Analytical methods for determination of fluoride in water samples

Analytical method	**Preparation**	**Detection limit**	**Reference**
Colorimetry	Dilute sample; add barium chloride; complex with zirconiumxylenol orange for color development	2,000 µg/L	[29]
Colorimetry	Sample added to sulfuric acid and distilled to remove interferences; distilled sample treated with SPADNS reagent; color loss resulting from reaction of reagent with fluoride is determined at 570 nm and concentration read off standard curve	0.10 mg/L	[30]
Colorimetry	Bellack distillationa , after which fluoride ion reacts with the red cerous chelate of alizarin complexone in an autoanalyzer	0.050 mg/L	[31]
Ion selective electrode	Mix sample and standard 1:1 with TISAB (for soluble fluorides)	0.500 mg/L	[32]
Ion selective electrode	No sample treatment required	0.100 mg/L	[32]

Analysis method adopted for determination of fluoride in water samples in the areas discussed in this paper are shown in Table 4.

Table 4: Analysis method adopted for fluoride in water sample in selected areas

Study area	No. of samples	Method used for F^- determination	Reference
Tamnar block, Raigarh	164	ion chromatograph (Metrohm, 861, Advanced Compact IC)	[23]
Kourikasa in Ambagarh Chouki block , Rajnandgaon	20	Orion Ion Analyzer-720 equipped with the ion-selective electrode using the buffer (TISAB-III)	[24]
Dongargarh, RJN	15	SPADNS	[4]
Balod	50	Metrohm ion meter-781 using the CDTA buffer	[25]
Surajpur	30	SPADNS	[26]
Domarpani village is located in a Narharpur block Kanker	41	Analysis was done by Public Health Engineering laboratory at district headquarter (Kanker)	[10]
Durg	168	Digital Ion Analyser equipped with a fluoride-selective electrode (Orion Research, Model 701A, Massachusetts) with buffer (TISAB) II	[27]

6. Fluoride concentration water ilected areas of Chhattiisgarh

6.1 Fluoride in Raigarh district

In Raigarh district the fluoridated area is a part of the Pahaj River watershed in Tamnar Block [23], where fluoride in water was first reported in 2004 by the Public Health Engineering Department of the State Government. Beg et al. reported that $F^−$ concentration in groundwater consistently exceeded the desirable and maximum permissible limits in three villages, viz. Muragaon, Pata and Saraitola. high F– concentration in groundwater mainly occurred in wells tapping the aquifers in Barakar Formation, which has a litho-assemblage of feldspathic sandstone/shale/coal. The positive correlation of $F^−$ with Na^+ and SiO_2, the groundwater type, increase in Na^+ : Ca^{2+} values with increase in F– concentration, presence of Li^+ in the high-$F^−$ zone, absence of $PO_3^{4−}$, and the results of mineralogical and petrographic analyses indicate that $F^−$ in groundwater is geogenic.

6.2 Fluoride in Rajnandgaon

In rajnandgaon district the ground water were collected from fifteen bore wells from different parts of the three blocks such as Dongargarh, Dongargoan and Rajnanadgaon in the month of January 2015 [4] out of which two sites of Dongargarh has fluoride more than permissible limit in water. In their paper of Nooel & Rajwade, 2015 [4] physicochemical parameters pH, Electrical conductivity (EC) and total dissolved solid (TDS) and total hardness (TH) was determined but they have not correlated these parameters with presence of fluoride in water samples.

In another stusy made by Patel et al., 2015 [24] water samples were collected from Kourikasa area of Ambagarh Chouki, Rajnandgaon (RJN) district in 2010-11. In this area average concentration of fluoride in water was 14.1 ± 3.1 which is several times more than the permissible limit. By statistical analysis they found that fluoride contamination of the groundwater seems to be related to the tube wells installed at shallow depth and, thus, to enrichment of shallow ground water by evaporation.

6.3 Fluoride in Surajpur

Upadhyay & Komal Kumari, 2013 [26] collected six water samples from each of five villages namely Baraul, Ramtirath, Banapatti, Barwahi and Fatehpur from Surajpur district for fluoride analysis. Out of these six samples three were surface and three were ground water samples.

In the study made by Upadhyay & Komal Kumari, 2013 [26], all the samples collected from five villages of Prem Nagar block of Surajpur showed fluoride concentration more than prescribed permissible limit. Water quality parameters such pH, temperature, conductivity, dissolves oxygen T.D.S. were analysed but they didn't report any correlation of these parameters with fluoride. Therefore source of fluoride is not detectable from this study.

6.4 Fluoride in Balod

Yadav et al., 2016 [25] reported fluoride contamination in ground water in Balod district. Samples were collected from Balod, Gurur, Gunderdehi, Dondi Lohara and Dondi block of Balod district. The physical parameters *i.e.* temperature (T), pH, dissolved oxygen (DO), reduction potential (RP) and electrical conductivity (EC) with Fe in samples were measured. Iron, fluoride, chloride and calcium were found more than the permissible limit in samples which made them not suitable for drinking purpose. This paper also reported skeletal fluorosis in Gunderdehi and Balod blocks. The source of fluoride in water in this area was found to be geogenic. Presences of fluoride bearing rocks are mainly responsible for the contamination. Mining and agricultural activities also contributes in enhancement of fluoride contamination in water sources of area.

6.5 Fluoride in Kanker

A survey report of fluorosis mapping was prepared by Dr. Gitte [10] of Domarpani village in Narharpur block of Kanker district. The objective of the survey was to determine the concentration of fluoride in drinking water and to find out the deformity caused by fluorosis in population of the area. Survey reported that dental fluorosis was common in teen age group whereas skeletal fluorosis was found in male and feamale above 45 years of age. The mean fluoride consentration in the ground water in the surveyed area was 2.19 and 98% of surved population is suffering from fluorosis there.

6.6 Fluoride in Durg

Giri et al., 2013 [27] made a cross sectional survey in 12 blocks of Durg district to determine the fluoride concentration in water. For the purpose, 168 water samples (7 groundwater samples and 7 surface water samples from each block) were collected. This paper considered that high concentration of fluoride in water is geogenic. The weathering and leaching process helps to increase fluoride contamination. Along with this industrial development of the area also contributes in fluoride contamination specially phosphate fertilizer factory and the brick kilns.

Fluoride concentration in areas discussed above and cause of fluoride in water samples there is summarized in Table 5.

Table 5: Fluoride concentration in parts of Chhattisgarh

Location	Min.	Max	Correlaton		Inference	Reference
			Positive	Negative		
Tamnar block, Raigarh	0.09	8.88	Na^+ and SiO_2	ca^{2+}, Mg^{2+},HCO_3^- , alkalinity and total hardness (TH)	The F^- rich groundwater in the study area is associated with Na-Ca-Mg-HCO_3 and Na-Mg-Ca-HCO_3 types of water	[23]
Ambagarh Chouki, RJN	3.7	27			Enrichment of shallow ground water by evaporation	[24]
Dongargarh, RJN	0.25	1.7	-	-	-	[4]
Premnagar Block, Surajpur	0.7	1.2	-	-	Geogenic contamination	[26]
Domarpani village in Narharpur block anker	0.5	2.86	-	-	-	[10]
Gunderdehi block, Balod	1.5	14	NO3-, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+	Cl^-, SO_4^{2-}, Fe	Positive correlation with the NH_4^+ , Na^+ , K^+ and Mg^{2+} ions, indicating existence of F− in the geo media as Barberiite, bararite, ferruccite, sellatite, cryolite, hieratite, etc. Other ions i.e. Cl^- , SO_4^{2-} , Na^+ , K^+ , Mg^{2+} and Ca^{2+} were partially correlated, showing origin from multiple sources i.e. geogenic, mining, agriculture, etc.	[25]
Durg	0.2	13.2	-	-	geogenic contamination, along with contamination from phosphate fertilizer factory and the brick kilns	[27]

7. Necessary steps to be taken to prevent fluorosis

7.1 Use of alternative sources of water

Water is the main source of fluoride intake in body. Fluoride is mainly geogenic contamination and ground water is the main source of drinking in Chhattisgarh. Therefore use of alternative of ground water such as surface water or rain water should be encouraged in villages.

Moreover fluoride is not evenly distributed in ground water. Its distribution depends on geological structure and depth of bore wells. Hence digging of new bore well in area of low fluoride concentration can provide safe drinking water tp population.

7.2 Development of methods of removal of fluoride from water

Various methods are available for defluoridation of water such as chemical precipattion, adsorption, ionic separation etc. Each and every method has its own advantages and disadvantages. As per the condition and requirement of a fluoride contaminated site proper method can be adopted for defluoridation.

7.3 Nutrition:

Proper measures can be taken to provide nutritional supplements to people suffering from fluorosis. As calcium has negative correlation with fluoride, intake of calcium supplements along with vitamin C, iron,antioxidants such as milk, curd, green leafy vegetables, fruits s is helpful for fluorosis patients.

7.4 Health Education and public awarenwss:

Awareness campaign should be run by government and health workerss to provide information on fluorosis, importance of drinking safe water and about healthy diet are important for prevention and control of fluorosis.High fluoride containing products such as Supari, tobacco, black rock salt, red rock, toothpaste, mouth wash etc. should be avoided.

8. Conclusion

Fluoride in ground water is primarily derived from decomposition, dissociation and dissolution of F^- bearing minerals, and occasionally from anthropogenic activities such as use of phosphatic fertilizers which have F^- as an impurity. Ascertaining the source of F^- in groundwater is essential for taking up mitigation measure. All the reported areas discussed in this paper have high fluoride concentration in water. Some papers not only identified the fluoride contaminated areas but also correlate it with geological structure and chemical composition of water. Rock structure of area and correlation matrix of fluoride with other physicochemical parameters helps to identify fluoride contamination in water sources, which in turns help to adopt proper preventive measure in contaminated area. Therefore identification of fluride in water, cause of fluoride contamination and development of removal method is essential to fight back the problem of fluorosis.

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