Original Article

# A Comparative Study of Skeletal Fluorosis among Adults in Two Study Areas of Bangarpet Taluk, Kolar

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## Abstract

**Background:** Skeletal fluorosis is a crippling disease resulting from excessive exposure to high fluoride from different sources. **Objectives:** To assess the prevalence of skeletal fluorosis in Bangarpet taluk of Kolar, to compare various epidemiological factors influencing the occurrence of skeletal fluorosis among the two groups with differential water fluoride levels, and to estimate fluoride levels in all the sources of drinking water in study areas. **Methods:** A cross-sectional study was conducted among the adults of three randomly selected villages of Bangarpet taluk, Thimmasandra, Batavarahalli, with high (>1.5 mg/L) and Maddinayakanahalli with normal (<1.0 mg/L) fluoride levels. A house-to-house survey was conducted by administering a semi-structured questionnaire. Skeletal fluorosis was assessed by three simple physical tests in the field followed by radiological confirmation among the positives. Fluoride levels of drinking water sources were estimated by the ion-electrode method. Chi-square and Fisher's exact tests were used as tests of association. **Results:** The prevalence of skeletal fluorosis at field level in both high and normal fluoride groups was 5.0%. Water fluoride levels in Thimmasandra, Batavarahalli, and Maddinayakanahalli were 4.13 mg/L, 2.59 mg/L, and 0.61 mg/L, respectively. Among the subjects with skeletal fluorosis, a significant difference was observed between socioeconomic status and prevalence of skeletal fluorosis in both high and normal fluoride groups ($P < 0.05$). **Conclusion:** Skeletal fluorosis is a threat among elderly in Bangarpet taluk, Kolar district.

**Keywords:** Fluoride, ion-electrode method, skeletal fluorosis

## Introduction

Skeletal fluorosis results from ingestion of high levels of fluoride and is known to occur in areas with excess fluoride concentrations in the drinking water predominantly sourced from ground water. It occurs when it involves the bone and major joints. Fluoride has a preferential affinity to accumulate in cancellous (spongy) bones, compared to compact (cortical) bones as cancellous bone has excellent blood supply than the cortical bone.[1,2]

The Bureau of Indian Standards has set a maximum desirable limit of fluoride in water as 1.0 mg/L and maximum permissible limit in the absence of alternate source as 1.5 mg/L.[3] The WHO reports that there is no clear estimation of the prevalence of skeletal fluorosis and is believed to affect millions of people. Fluorosis

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is found to be endemic in at least 25 countries across the globe. The fluoride belts stretch from Syria through Jordan, Egypt, Libya, Algeria, Sudan and Kenya, and another that stretch from Turkey through Iraq, Iran, Afghanistan, India, Northern Thailand, and China where fluorosis has been reported, and similar belts are also found in Americas and Japan. Drinking water being the most significant source exposure to multiple sources of fluoride such as food, water, air (due to gaseous industrial waste), and excessive use of toothpaste and a person's diet, general state of health, as well as the body's ability to dispose fluoride, all affects the development of fluorosis.[4,5]

India lies along the geographical fluoride belt and has 21 states as it is a home for fluorosis.[6] 40–70% districts are affected in Bihar, National Capital Territory of Delhi, Haryana, Jharkhand, Karnataka, Maharashtra, Madhya Pradesh, Odisha, Tamil Nadu, and Uttar Pradesh.[7] Majumdar in West Bengal reported 6.6–26.2% prevalence of manifestations of skeletal fluorosis.[8] Garg, in Agra, documented 18.46% prevalence of skeletal fluorosis in adults and the male subjects showed the relatively higher prevalence of skeletal fluorosis.[9] Jolly *et al*. in Punjab found an incidence of 2.4% skeletal fluorosis among adults for skeletal fluorosis and was found to increase with age. Sex and occupation also had some influence on the development of endemic fluorosis.[10] Nirgude *et al*. in Nalgonda, Andhra Pradesh, found an overall prevalence of 24.9% skeletal fluorosis which was more among males, illiterates, laborers and farmers, tobacco users, and alcohol abusers. The prevalence of skeletal fluorosis was found to increase with age and was also associated with lower socioeconomic status ($P < 0.05$).[11] A study conducted by Choubisa *et al*. reported that among subjects with poor nutrition, the prevalence of skeletal fluorosis was 23.9%. The highest incidence of skeletal (60.8%) fluorosis was observed in alcohol or beverage users and the lowest (30.8% and 8.9%) in the citrus fruits users. The data pertaining to the relationship of osteo-dental fluorosis with nutritional status, living habits, and occupation were statistically analyzed and were found to exhibit highly positive correlations.[12] Shivashankara *et al*. in Gulbarga district, Karnataka, estimated the fluoride concentration in drinking water by zirconium – SPADNS spectrophotometric method and cross-checked the same with a fluoride ion selective electrode (ORION 710-A) which ranged from 0.6 to 13.4 ppm and 39% of them exhibited skeletal fluorosis.[13] Arvind *et al*. in the rural areas of Kaiwara Hobli, Chikkaballapur district, Karnataka, reported 8.4% prevalence of genu valgum.[14] Kolar has been reported to have 26,000 people suffering from dental and skeletal fluorosis.[15]

Beyond these existing data, there is a dearth in the literature on the prevalence of skeletal fluorosis and epidemiological factors responsible for skeletal fluorosis existing in the Southern part of Kolar, and hence the present study was taken up. Moreover, Kolar has been considered as one among the 16 fluorosis endemic districts of Karnataka and is a drought prone area with a semi-arid climate. In addition to this, the residents mainly depend on ground water for drinking and domestic purpose, an added risk factor for fluorosis.[16,17] Radiological changes in skeletal fluorosis usually manifest at puberty and in adulthood.[18] Hence, the study was conducted among adults with the following objectives. first, to assess the prevalence of skeletal fluorosis in the study population. Second, to compare the various epidemiological factors influencing the occurrence of skeletal fluorosis among the two groups with differential water fluoride levels, and lastly, to estimate fluoride levels in all the sources of drinking water in two study areas.

## Materials and Methods

It was a cross-sectional study which was conducted for a period of 1-year from December 1, 2011, to November 30, 2012. The study was conducted among the three villages of Bangarpet taluk, Kolar district, namely Thimmasandra, Batavarahalli, and Maddinayakanahalli. All the three villages are located around 20 km toward South from the district headquarters of Kolar and 74 km from the state capital Bengaluru, Karnataka [Figure 1].[19-21]

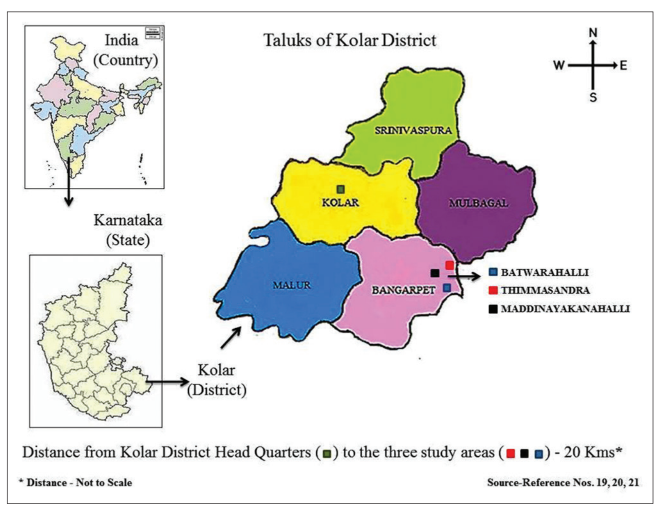


**Figure 1:** Area map depicting the three study areas

Fluoride estimation is being routinely done in Kolar district by the office of the executive engineer, Kolar in 10–15% of the drinking water sources. As per the report, Bangarpet taluk was selected as it recorded the highest number of villages with fluoride level >1.5 mg/L. All the villages in Bangarpet taluk were listed in two groups, one group with fluoride level >1.5 mg/L (high fluoride) and another group with fluoride level <1.0 mg/L (normal fluoride).

First, the village in the high fluoride group, Batavarahalli comprising 133 populations was randomly selected; second in the normal fluoride group, Maddinayakanahalli comprising 588 populations was randomly selected. As there was an unequal representation of population in two groups, one more village from high fluoride group, i.e., Thimmasandra comprising 471 populations was randomly selected from the list. Pregnant women, bedridden, and the persons who were not available even after two visits were excluded from the study.

Ethical clearance was obtained from the Institutional Ethical Committee. A house-to-house survey was conducted to estimate the prevalence of skeletal fluorosis among all the household adults. After obtaining informed consent in local verbatim, the data were recorded in a pretested, semi-structured, validated questionnaire consisting of the sociodemographic profile and few questions on certain risk factors of skeletal fluorosis, namely sources of water for drinking, cooking and other domestic purposes, type of foods consumed, and use of fluoride-containing products. Socioeconomic status was calculated using modified B G Prasad classification using all India wholesale price index for all commodities for the month of October 2012.[22,23] Weight and height were measured adopting the standard procedures and body mass index was calculated and categorized using the WHO Asia-Pacific guidelines and "underweight," "overweight," and "obesity" were again categorized as malnourished and "normal" as belonging to normal nutritional status.[24]

Skeletal fluorosis was assessed using the three field tests, namely (a) touching the toes without bending the knees, (b) touching the chest with the chin, and (c) stretching the arms sideways and folding the arms to touch the back of the head. Subjects who were unable to perform the three simple diagnostic tests due to pain or stiffness in the neck or pain or stiffness in the shoulder joint and backbone, respectively, were subjected for radiological evaluation for skeletal fluorosis and radiographs of the forearm were taken. The evaluating radiologist was blinded to the clinical symptoms of the subjects. The interosseous membrane calcification in the forearm was identified and diagnosed as skeletal fluorosis by the radiologist and orthopedician.[2,25]

Water samples were collected in 1 L plastic bottles, labeled, coded, and were sent to the Indian Institute of Science (IISc), Bengaluru, for the analysis of fluoride levels by ion selective electrode method. The ion electrode instrument was calibrated before testing for fluoride levels. Ten milliliters of samples was taken in a beaker at 10 ml fluoride buffer solution. The stirring bar was put, and the electrode was immersed into the beaker. The magnetic stirrer was started for stirring at a constant rate. The reading was recorded after it was stabilized. The electrode was washed with the distilled water after use.[26]

The data were analyzed using the standard statistical package. The proportion of skeletal fluorosis and the association of skeletal fluorosis with selected individual risk factor were analyzed using appropriate tests, namely Chi-square, Fisher's exact test. A $P < 0.05$ was taken as statistically significant.

## Results

### *Sociodemographic details*

After applying the exclusion criteria, there were 358 and 322 study participants in high and normal fluoride groups, respectively. The age of the study subjects ranged between 20 and 90 years among both high and normal fluoride groups. Males and females were equally distributed in both the study groups. Mean consumption of drinking water among the high fluoride group was 3.52 ± 0.51 L and in the normal fluoride group was 3.6 ± 0.53 L.

### *Prevalence of skeletal fluorosis*

The prevalence of skeletal fluorosis at the field level in both the groups with high and normal fluoride was 5.0%. In the high-fluoride group, the prevalence of skeletal fluorosis among males and females was 4.81% and 5.26% whereas, in the normal fluoride group, the prevalence of skeletal fluorosis among males and females was 6.21% and 3.10%, respectively. However, the difference in the prevalence of skeletal fluorosis among males and females in both high and normal fluoride groups was not statistically significant ($P > 0.05$) [Table 1].

The age-specific prevalence rate showed that as age increased, the prevalence rate of skeletal fluorosis also increased [Table 2].

Twelve (66.7%) and 14 (93.3%) of them in the high and normal fluoride groups had pain and stiffness in the joints. The skeletal fluorosis after X-ray confirmation was found among 2 (11.11%) adults of which one was male aged 90 years and the other was female aged 80 years in the high fluoride group, and no X-ray changes were seen in the normal fluoride group [Figure 2].

### *Water fluoride levels in drinking water sources of different study areas*

The high fluoride group included the subjects from Thimmasandra and Batavarahalli villages, and the normal fluoride group included the subjects from Maddinayakanahalli village with a public bore well as the only source in all the villages. The water fluoride levels analyzed by the ion-electrode method obtained from IISc, Bengaluru, were 4.13 mg/L, 2.59 mg/L, and 0.61, respectively.

### *Comparison of various epidemiological factors influencing the occurrence of skeletal fluorosis*

Among the subjects with skeletal fluorosis, majority, i.e., 26 (78.8%) of them belonged to a poor class, and a significant difference was observed between socioeconomic status and prevalence of skeletal fluorosis in both high and normal fluoride groups ($P < 0.05$). There was no association of gender, occupation, castes, and educational status with the prevalence of skeletal fluorosis ($P > 0.05$). None of the study subjects with skeletal fluorosis used fluoridated medicines among both high and normal fluoride groups. The prevalence of skeletal fluorosis was not significantly associated with the risk factors, namely quantity of water consumed, use of fluoridated dental products for dental cleaning, use of fluoridated medicine, tobacco or areca nut users, and the nutritional status of the study subjects ($P > 0.05$) [Table 3].

## Discussion

Skeletal fluorosis is a crippling disease and is a threat among elderly. The geographical risk factors of Kolar such as semi-arid climate, drought prone, and other risk factors such as dependency on ground water with fluoride above permissible limits as a sole source for drinking and/or cooking purpose, consumption of drinking water directly without any treatment, use of fluoridated toothpaste for dental cleaning, use of fluoride containing medications, chewing tobacco/areca nut, smoking, and failure in the community involvement in the maintenance of installed defluoridation units adds to this threat.

The prevalence of skeletal fluorosis in the present study was same, i.e., 5.0% among both high and normal fluoride groups. Bharati *et al*., in Gadag and Bagalkot districts of Karnataka, found the prevalence of skeletal fluorosis to be 5.45% in Mundargi taluk in which the fluoride level ranged from 4.0 to 10.5 ppm.[27] The prevalence of manifestations of skeletal fluorosis was found to be 6.6–26.2% in a study conducted by Majumdar, in two fluoride endemic blocks of West Bengal, India.[8] One of the reasons for the skeletal fluorosis to prevail in the normal fluoride group may be due to the fluoride ingestion through food; however, it needs further in-depth analysis of the foods consumed by the study subjects.


**Figure 2:** X-ray of both forearms showing the interosseous membrane calcification in anteroposterior view

**Table 1: Prevalence of skeletal fluorosis based on three simple physical tests at the field level**

| Skeletal fluorosis | Fluoride level >1.5 mg/L | | | Fluoride level <1.0 mg/L | | | Prevalence | $\chi^2$ | $P$ |
|---|---|---|---|---|---|---|---|---|---|
| | Males (%) | Females (%) | Total (%) | Males (%) | Females (%) | Total (%) | | | |
| Present | 9 (4.8) | 9 (5.3) | 18 (5.0) | 10 (6.2) | 5 (3.2) | 15 (4.7) | 5.0 | 0.05 | 0.82 |
| Absent | 178 (95.2) | 162 (94.7) | 340 (95.0) | 151 (93.8) | 156 (96.8) | 307 (95.3) | | | |
| Total | 187 (100.0) | 171 (100.0) | 358 (100.0) | 161 (100.0) | 161 (100.0) | 322 (100.0) | | | |

Majumdar and Sundarraj, in an interventional study on fluorosis endemic village of West Bengal, the most common signs among individuals consuming the water with fluoride concentration above permissible limit with skeletal fluorosis were pain and stiffness of the joints (43.26%) similar to the present study finding.[28]

The age-specific prevalence rate showed that as age increased, the prevalence rate of skeletal fluorosis also increased which is analogous to a study finding in a cross-sectional survey conducted by Pandey in Gureda village of the Durg district of Chhattisgarh, in which the prevalence of skeletal fluorosis increased with age where the water fluoride levels ranged from 0.2 to 7.8 ppm.[29]

The prevalence of skeletal fluorosis was nearly similar in both the sexes which are analogous to a study finding conducted by Gitte *et al*. in an epidemiological study of fluorosis in a village of Chhattisgarh where the water fluoride levels ranged from 0.1 to 7.3 ppm.[30]

Choubisa *et al*. reported that in villages of Banswara, Dungarpur, and Udaipur districts of Southern Rajasthan, on X-ray, 2–3 fluorotic subjects of each village showed an increased bone mass and density along with exostoses, calcification of ligaments and interosseous membranes, and osteosclerosis, parallel in the present study, two of them in the high fluoride group showed the interosseous membrane calcification on X-ray.[12]

Nirgude *et al*., in Nalgonda in 2008–2009, have got more cases of skeletal fluorosis among lower socioeconomic status (69.1%) and illiterates (37.6%) and Dhurvey and Dhawas, in Chandrapur, Maharashtra, in 2010–2011, subjects were mostly illiterate and socioeconomically backward and poor, which are similar to the present findings.[11,31]

Sixteen (48.5%) of them belonged to scheduled caste/other backward castes and 17 (51.5%) of them belonged to general category among the study subjects with skeletal fluorosis which is in contrast to the findings made by Choubisa *et al*. in a study on fluorosis in subjects belonging to different ethnic groups of Rajasthan. This needs an in-depth evaluation for the fluoride exposure

**Table 2: Age-specific prevalence rate of skeletal fluorosis**

| Age in years | Total study population (*n*) | Total population with skeletal fluorosis (*n*) | Age-specific prevalence rate of skeletal fluorosis (%) |
|---|---|---|---|
| <56 | 570 | 1 | 0.17 |
| 56-65 | 69 | 14 | 20.29 |
| 66-75 | 28 | 10 | 35.71 |
| 76-85 | 10 | 6 | 60.00 |
| >85 | 3 | 2 | 66.67 |

**Table 3: Relationship between various socio-epidemiological factors with skeletal fluorosis in two areas with differential water fluoride levels**

| Particulars | Fluoride level >1.5 mg/L (%) | Fluoride level <1.0 mg/L (%) | Total (%) |
|---|---|---|---|
| Gender§ (*n*=33) | | | |
| Males | 9 (47.3) | 10 (52.7) | 19 (100.0) |
| Females | 9 (64.3) | 5 (35.7) | 14 (100.0) |
| Socioeconomic status*,+ (*n*=33) | | | |
| Lower middle | 7 (100.0) | 0 (0.0) | 7 (100.0) |
| Poor | 11 (42.3) | 15 (57.7) | 26 (100.0) |
| Caste§ (*n*=33) | | | |
| Scheduled caste/other backward castes | 11 (68.7) | 5 (31.3) | 16 (100.0) |
| General category | 7 (41.2) | 10 (58.8) | 17 (100.0) |
| Quantity of drinking water consumed per day in liters+ (*n*=33) | | | |
| ≤2 | 15 (57.7) | 11 (42.3) | 26 (100.0) |
| >2 | 3 (42.8) | 4 (57.2) | 7 (100.0) |
| Items used for dental cleaning§ (*n*=33) | | | |
| With fluoride | 6 (54.5) | 5 (45.5) | 11 (100.0) |
| Without fluoride | 12 (54.5) | 10 (45.5) | 22 (100.0) |
| Consumption tobacco/areca nut§ (*n*=33) | | | |
| Yes | 7 (63.6) | 4 (36.4) | 11 (100.0) |
| No | 11 (50.0) | 11 (50.0) | 22 (100.0) |
| Malnourished (*n*=23)**,*,+ | | | |
| Yes | 4 (44.4) | 5 (55.6) | 9 (100.0) |
| No | 10 (71.4) | 4 (28.6) | 14 (100.0) |

*n*=Total number of study subjects, *$P$=0.009 (<0.05), +Fisher's exact test, §Chi-square test, **Height of the ten individuals could not be assessed because of bent spine, hence *n*=23 through nutritional components of diet and feeding habits of the subjects residing in the study areas.[32]

Among the subjects with skeletal fluorosis, 26 (78.8%) of them consumed ≤2 L and 7 (21.2%) of them consumed >2 L of water, 11 (33.3%) of them used items with fluoride and 22 (66.7%) of them used items without fluoride for the dental cleaning. However, there may be other confounders or effect modifiers such as diet and the biological factors which may be acting which also needs detail evaluation.

Dhurvey and Dhawas found the prevalence of skeletal fluorosis in 19.85% of habitual tobacco users similarly in the current study, 11 (33.3%) of the subjects with skeletal fluorosis were tobacco/areca nut users, and 22 (66.7%) of them did not use tobacco/areca nut. There may be an under-reporting of tobacco users as many study subjects might not reveal the tobacco use. Majumdar, in an interventional study in fluoride endemic rural area of Birbhum district of West Bengal, has found 14.3–19.5% of tobacco users affected with fluorosis.[31,33]

Among 33 individuals with skeletal fluorosis, the height of the ten individuals could not be assessed because of the bent spine and hence, 23 study participants were assessed for the nutritional status. Of the 23 study subjects with skeletal fluorosis, 9 (39.1%) of them were malnourished and the rest 14 (60.9%) were of normal nutritional status. Choubisa *et al*. reported a prevalence of 23.9%, among the subjects with poor nutrition and the data pertaining to the relationship of osteo-dental fluorosis with nutritional status were statistically analyzed and were found to exhibit highly positive correlations.[12] Although we have categorized the nutritional status, we could not assess for the micronutrient deficiency.

An annual average is a better indicator of fluoride levels in sources of drinking water which could not be performed in the present study. Urinary fluoride levels for the confirmation of consumption of fluoride-rich water/food could not be analyzed due to constraints of time, financial support, and logistics. Although we have taken the history of the use of fluoridated toothpaste, fluoridated mouth rinse, infant milk formulas, it needs an in-depth analysis of fluoride levels in the foods consumed, in addition to detailed diet survey to confirm the cause of fluorosis which could not be performed due to operational feasibility. There were 19 (57%) dropouts for the procedure of radiological confirmation even after repeated visits and motivation.

## Conclusion

Skeletal fluorosis being prevalent in 5% of the adults is a preventable disease that affects their livelihood. Hence, there is a need to take immediate measures to prevent skeletal fluorosis through the installation of community defluoridation units and inculcating better practices by providing health education using various effective medias about the problem of this preventable disease among the residents of Bangarpet taluk, Kolar district.

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### *Conflicts of interest*

There are no conflicts of interest.

## References

1. Jarvis HG, Heslop P, Kisima J, Gray WK, Ndossi G, Maguire A, *et al.* Prevalence and aetiology of juvenile skeletal fluorosis in the south-west of the Hai district, Tanzania – A community-based prevalence and case-control study. Trop Med Int Health 2013;18:222-9.
2. Susheela AK, editor. Fluorosis: An easily preventable disease through practice of interventions. In: Doctor's Handbook. 1st ed. New Delhi: Ministry of Health and Family Welfare (GOI) and WHO India Country Office; 2005. p. 1-21.
3. BIS. Draft Indian Standard Drinking Water – Specification (First Revision of IS 10500). Bureau of Indian Standards; 1991. Available from: https://www.law.resource.org/pub/in/bis/is.10500.1991.pdf. [Last cited on 2015 Jan 23].
4. World Health Organization. Water Sanitation and Health. Geneva: WHO; c2015. Available from: http://www.who.int/water_sanitation_health/diseases/fluorosis/en/. [Last cited on 2015 Oct 16].
5. UNICEF. Fluoride in Water – An Overview. Vol. 13. India: UNICEF; 1999. p. 11-3. Available from: http://www.nofluoride.com/Unicef_fluor.cfm. [Last cited on 2015 Jan 23].
6. Arlappa N, Qureshi AI, Srinivas R. Fluorosis in India: An overview. Int J Res Dev Health 2013;1:97-102.
7. Susheela AK. Fluoride and Fluorosis – National Prevalence. Available from: http://www.fluorideandfluorosis.com/fluorosis/Prevalence.html. [Last updated on 2012 Feb 28; Last cited on 2015 Jan 23].
8. Majumdar KK. Prevalence of fluorosis and pattern of domestic filters use in two fluoride endemic blocks of West Bengal,

India. J Compr Health 2015;3:17-30.
9. Garg S. Prevalence of fluorosis among children and adults. Int J Pharm Res Innov 2011;4:25-31.
10. Jolly SS, Singh BM, Mathur OC, Malhotra KC. Epidemiological, clinical, and biochemical study of endemic dental and skeletal fluorosis in Punjab. Br Med J 1968;4:427-9.
11. Nirgude AS, Saiprasad GS, Naik PR, Mohanty S. An epidemiological study on fluorosis in an urban slum area of Nalgonda, Andhra Pradesh, India. Indian J Public Health 2010;54:194-6.
12. Choubisa SL, Choubisa L, Choubisa D. Osteo-dental fluorosis in relation to nutritional status, living habits, and occupation in rural tribal areas of Rajasthan, India. Res Rep Fluoride 2009;42:210-5.
13. Shivashankara AR, Shankara SY, Rao HS, Bhat GP. A clinical and biochemical study of chronic fluoride toxicity in children of Kheru Thanda of Gulbarga district, Karnataka, India. Fluoride 2000;33:66-73.
14. Arvind BA, Isaac A, Srinivasa NM, Shivaraj NS, Suryanarayana SP, Pruthvish S. Prevalence and severity of dental fluorosis and genu valgum among school children in rural field practice area of a medical college. Asian Pac J Trop Dis 2012;2:465-9.
15. Valdiya KS. Finding causes of diseases – Medical geology. Geology, Environment, and Society. Hyderabad: Universities Press (India) Private Limited; 2004. p. 201-11.
16. Susheela AK. District Endemic for Fluorosis. Available from: http://www.fluorideandfluorosis.com/fluorosis/Districts.html. [Last updated on 2012 Feb 28; Last cited on 2015 Jan 23].
17. Mamatha P, Rao SM. Geochemistry of fluoride rich in groundwater in Kolar and Tumkur districts of Karnataka. Environ Earth Sci 2010;61:131-42.
18. Reddy DR, Deme SR. Skeletal fluorosis. In: Ramamurthi B, Tandon PN, editors. Ramamurthi and Tandon's Textbook of Neurosurgery. 3rd ed. New Delhi: Jaypee Publishers; 2012. p. 1312-32.
19. Census2011.co.in. Census, Inc.; c2015. Available from: http://www.census2011.co.in/data/subdistrict/5593-bangarapet-kolar-karnataka.html. [Last cited on 2015 Oct 16].
20. www.onefivenine.com. Inc.; c2013. Available from: http://www.onefivenine.com. [Last cited on 2015 Oct 16].
21. Area Map. Bethmangala and Oorgaumpet Primary Health Centre Records; 2012.
22. Office of the Economic Adviser, Government of India. Whole Sale Price Index. Available from: http://www.eaindustry.nic.in/display_data.asp. [Last updated on 2015 Aug 25; Last cited on 2015 Aug 13].
23. Agarwal AK. Social Classification: The need to update in the present scenario. Indian J Community Med 2008;33:50-1. Available from: http://www.ijcm.org.in/text.asp?2008/33/1/50/39245. [Last cited on 2015 Aug 13].
24. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157-63.
25. Susheela AK. Epidemiological studies of health risks from drinking water naturally contaminated with fluoride. Int Assoc Hydrol Sci 1995;233:123-34.
26. Yadav AK, Khan P. Fluoride and fluorosis status in groundwater of Todaraisingh area of district Tonk (Rajasthan, India). Int J Chem Environ Pharm Res 2010;1:6-11.
27. Bharati P, Kubakabaddi A, Rao M. Clinical symptoms of dental and skeletal fluorosis in Gadag and Bagalkot districts of Karnataka. J Hum Ecol 2005;18:105-7.
28. Majumdar KK, Sundarraj SN. Health impact of supplying safe drinking water on patients having various clinical manifestations of fluorosis in an endemic village of West Bengal. J Family Med Prim Care 2013;2:74-8.
29. Pandey A. Prevalence of fluorosis in an endemic village in central India. Trop Doct 2010;40:217-9.
30. Gitte SV, Sabat R, Kamble K. Epidemiological survey of fluorosis in a village of Bastar division of Chhattisgarh state, India. Int J Med Public Health 2015;5:232-5.
31. Dhurvey V, Dhawas S. Skeletal fluorosis in relation to drinking water, nutritional status and living habits in rural areas of Maharashtra, India. IOSR J Environ Sci Toxicol Food Technol 2014;8:63-7.
32. Choubisa SL, Choubisa L, Sompura K, Choubisa D. Fluorosis in subjects belonging to different ethnic groups of Rajasthan, India. J Commun Disord 2007;39:171-7.
33. Majumdar KK. Health impact of supplying safe drinking water containing fluoride below permissible level on patients having various clinical manifestations of fluorosis in a fluoride endemic rural area of Birbhum district of West Bengal. Indian J Public Health 2011;55:303-8.