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The Dental fluorosis on Santana karst region, Bahia State, Brazil

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Abstract

This paper presents the research results obtained by studying the natural fluoride contamination of underground water and dental fluorosis observed in the universe of the population of the municipality of Santana, Bahia, Brazil. The levels of fluoride chlorides, sulfates, nitrates and nitrites were obtained by systematic sampling from underground wells and water complemented through the Brazilian System Water data (SIAGAS). Confirmation of endemic condition was assessed in a population of 159 adolescents, aged 12 years. The universe of the population was estimated at 118 adolescents using simple random sampling technique without replacement (AASS), with ratio estimator (prevalence) in the amount of 0, 815, confidence level of 90% and margin of error ±5%. The teenagers were interviewed based on a structured questionnaire and the prevalence and severity of fluorosis were obtained through the Dean index (Dean, 1934). The clinical examination and the questionnaire were carried out in schools, elementary school, the communities in the municipality of Santana-BA, performed by a trained dental surgeon with k = 0.85 (kappa). It found the prevalence to the municipality of 53% and the severity for moderate / severe degree of 17.7%, plus a strong association between the occurrence of dental fluorosis and the places where fluoride levels are. The fluoride content in almost every area were above the established (1.5 F mg/L) by Ordinance 2914/11 of the Brazilian Ministry of Health. The localities that showed the highest risk dental prevalence were Barreiro Fundo, Jacaré, Sossego, Pedra Preta, Caracol, Tapera e Várzea do Mourão.

Keywords: Dental Fluorosis. Fluoride. Risk. Prevalence. Severity.

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Introduction

Water as well as being a major component for cellular metabolism of human functions, also participates in geochemical change processes of rocks. About a quarter of the countries facing problems related to water supply (Carneiro et. al. ,2008). Brazil has one of the largest freshwater reserves on the planet, yet not always the existence of this feature ensures the possibility of use by its inhabitants. The hydrography of the municipality of Santana region, State of Bahia, Brazil (Figure 1) although broad, is not permanent and the population uses the water from groundwater. These, in turn, are often contaminated by chemicals of geogenic and anthropogenic origin, occasionally harmful to health, directly influencing the prevalence and incidence of disease.

The incorporation of inorganic chemicals to the groundwater occurs primarily by dissolution and modification of rocks, the example has been fluoride which is readily absorbed in the human body cells. This element, when consumed in high concentrations, can produce a disease termed the teeth of dental fluorosis and in extreme cases changes in skeletons are developed, called skeletal fluorosis. This halogen, when consumed in low amounts and often becomes a viable means for the prevention of dental caries lesion as well as increased bone strength matrix (Fejerskov et. al. , 1994). Brazil has the second largest system in the world public water supply fluoridation, in force since the year 1974. This measure which established mandatory fluoridation where there was water treatment (BRAZIL, 2010). Based on this fact, RAMIRES et. al. (2007) warned that despite the benefits of fluoridation of drinking water to prevent tooth decay, observed a tendency to increase in the occurrence of dental fluorosis due to fluoride cumulative effect of geogenic origin.

In Santana opened in 1998 the SIAA-Integrated Water Supply, including, from this year the fluoridation process. However, the Municipal Health of Santana reports the existence of several cases of dental fluorosis. This finding, similar to endemic that occurs in São Francisco region,Minas Gerais State, Brazil. (GONÇALVES 2014). This article presents the results of research on dental fluorosis developed skin community consuming water with high fluoride concentrations, held in the municipality of Santana, Western Bahia, Brazil, and contributes to knowledge in the field of medical geology.

Overview of Santana Region

The region of Far Western Bahia until the first half of the twentieth century, had low economic level and only from the 70s has undergone rapid transformation process due to the expansion of the agricultural frontier in the midwest of Brazil, in addition to receiving a large population movement from other regions of the country (SANTOS et al. 2000). Nowadays, this area is a major economic province highlighting livestock, grain production and horticulture.

This process of development has been driven by plans and fertile soils, favorable weather conditions, with moderate rainfall and mild temperatures, besides the strong government intervention in the form of infrastructure deployment policies, irrigation, land and credit (BAIARDI, 2004).

The Santana municipality is located 813 km from Salvador, in the southwest of Bahia (Figure 1), has an area of 1914.7 square kilometers (SEI, 2000), population around 27,263 inhabitants, with a population density of 14.24 inhab./km^2 and Human Development Index (HDI) of 0.645, corresponding to the average in grade and occupying the 119 position relative to Bahia State ranking (IBGE, 2010).The population is around 14,858 inhabitants living in the municipal headquarters (54.4%) and 12,405 occupying the countryside (45.5%) (IBGE, 2010). The rural population is distributed in 73 locations and approximately 3,452 households. The main locations are Porto Novo villages (400 households), Areião (144 households), the Baixão do Cedro (108 households) and Pedra Pedra (104 households).

The town of Porto Novo, despite the distance of approximately 57 km from the district headquarters, has attracted lot of residents to its perimeter, as have two school-core high school and elementary and lie on the river current surroundings, which in addition to landscape aspect is characterized as a major leisure facilities in the municipality. The locations of Areião, Baixão do Cedro are contrasted by the poor conditions of subsistence, where family farming is presented weak due to the constant drought.

Regarding the population group of children and adolescents in the municipality of Santana is around 8,654 souls under the age of 19 years, which corresponds to almost 32% of the population. Of these, more than half (5,112) are aged around 12 years of age (Table 1). The growth of the population, this age group was heavily influenced by economic growth, driven by the growth of the agricultural frontier and modernization of the agro-industrial sector of western Bahia.

This population group uses 34 schools distributed in the Santana city and at the following locations: Cachoeira, Ananás, Curral das Varas, Sossego, Umburana, Porto Novo, Canabrava, Caraíbas, Cedro, Brejinho, Alto do Santana, Alto da Vitoria, Sitio do Meio, Riachão, Galheiro, Jacarandá, Baraúna, Cocos, Baixa Funda, Boa Vista, Barreiro Fundo, Areão, Cipó, Pedra Preta, Tamboril, Limoeiro.

Hydrogeological Aspects

The hydrogeological overview of the region is characterized by two main aquifer systems: the areas of the porous aquifers and karst area (Bambuí Group, Dardenne, 1978).

The fields of porous aquifers are basically represented by recent sediments and alluvium. The sediments are made up of deposits of tertiary-quaternary covers are of secondary importance from the hydrogeological point of view, not only by the nature of its sediments, as well as by the limited outcropping area in the region. The alluviums are deposited in the troughs of rivers, extending for tens or even hundreds of meters, and its banks forming the ancient terraces. The water recharge of these takes place directly through rainfall, with lateral contributions from the drainage network, especially during floods. Because of its restricted and charging irregularity occurrence, directly conditioned by rainfall, these aquifers have importance as localized water sources (CODEVASF, 1989).

In the region in question the aquifer has strong karstification process of carbonate rocks. This karst rocks represent the best of groundwater storage possibilities and are related to the carbonate rocks of the Bambuí Group. According to PDRH (1995) on the Corrente basin the wells of Santana region have average values of depth around 91.42 m, average flow of 12.58 m^3/H and specific production capacity of 11.03 m^3/h.

Water Supply

The hydrographic network of Santana region is characterized by presenting watercourses that drain directly to the channel of the São Francisco River. Numerous small intermittent streams, which flow rates are directly related to rainfall, remain dry for several months. The main river is the chain, which features perennial character and is known for excellent water quality, suitable for various uses, with low chloride content, hardness, turbidity and suspended matter, including low fluoride content (SRH, 1995). The integrated water supply system was implemented in 2008 by EMBASA - Company Bahia Water and Sanitation, which makes the capture of Corrente river waters in Porto Novo town and distributes its waters for localities and municipalities, the following order: Gameleira, Canabrava in Santana, Serra Dourada, Tabocas do Brejo Velho and Brejolândia in Canápolis municipality.

The Corrente River was chosen as the best option for the supply depending on the quality of its waters and the permanence of flow rates. Before installing the SIAA, all enrolled region to the municipality of Santana used groundwater exclusively. It is noteworthy that the other locations of the city still do not receive the SIAA waters. The old municipal headquarters supply system Santana was made through the collected water in three (03) deep wells drilled in the region, and two wells were the Areião System, with total capacity of 180 m^3 / h, and a third well called system of Boa Viagem, with capacity of 130 m^3 /h in both wells evaluated fluoride levels had levels higher than allowed by ordinance 2916/2011 of the Ministry of Health of Brazil (1.5 mg F/L).

In rural schools have also installed the cistern rainwater capture, however, the directors reported not using because of the large amount of bats that reside on the roofs and deposit their feces where rainwater is captured. In the resident population municipal seat does not suffer from lack of water, however, in other places, natural water resources have low quality and the aspect of potable for human consumption, in view of the presence of flow of sewage on public roads and in natural drainage, similar to what occurs in most of the county seat of households throw their waste into the existing storm drainage system, especially in Santana, which cuts the city. The public sewer system is summed up in a few individual systems such as septic tank with sink.

Hydrogeochemistry Groundwater

The water chemistry analysis is often used to assess its quality, and is directly associated with the same features as its use (FENZL, 1988). Water samples collected in Santana region and analyzed the Instituto de Geociências da Universidade Federal da Bahia, Brazil laboratories of cations (Na +, Ca + 2, Mg + 2 and anions Cl, SO_4-^{2e} HCO^{-3} .The K+, NO^{-3} , CO_3^{-2} have low levels or even being absent The research reported priority was given to checks on nitrate concentrations, nitrites, chlorides, sulfates and fluorides. These components were analyzed in 55 locations plus the county seat, totaling 56 sampling points from a total of 73 existing locations in the city. For the nitrite ion the analysis was performed in only 15 locations.

The Tables 1 and 2 shows the results of physical and chemical measurements of the main elements: nitrates, chlorides, sulfate and fluorides, which also presents a statistical summary and the limits for drinking water recommended by the Brazilian MS 2914/2011 to the physico-chemical parameters under review. For ratification of analytical results was used as the basis for interpretations analytical values SIAGRAS and Gonçalves (2014). Table 3. The average levels of cations and anions were, respectively, in descending order: rCl-> rSO_4^2-> RF-> rNO_3-. The ionic charge balance, based on the practical error (Ep), defined by Logan (1965), the groundwater samples collected revealed error below 10%, except for one sample which tested deficit anions around 20%. This error is probably due to the presence of organic anions not assessed.

The groundwater nitrate levels present on halftone levels around 0.03 mg/L found in the well of Luiz Martins location and reach the maximum numerical value around 5.40 mg/L in the well of Gameleira. The arithmetic mean of nitrate analysis is 0.6 mg/L and a median of 0.46 mg/L. The 108.70 coefficient of variation, expressed great variability in nitrate content of the samples following this not a normal distribution. Small nitrate levels in most samples may reflect contamination from the decomposition of soil organic matter.

The content analyzed maximum levels (5.40 mg/L) in Gameleira pit waters can be explained by the lack of a network of sewage collection and proximity to dwellings that flow directly from the waste stream located near the well.For nitrite the maximum analyzed was 0.23 mg/L, found in the locality of Pedra Preta and trough concentrations were obtained in the towns of Baixão do Cedro and Caracol 0.01 mg /L. The calculated average is 0.05 mg/L, median 0.03 mg/L and the coefficient of variation 117.06%, these contents being suggestive of a distribution of outliers. The nitrite analysis, regardless of the concentration in groundwater, it is difficult to obtain because it is subject to oxidation and thus be transformed into nitrate.

The chloride concentrations ranging from minimum levels of about 5.3 mg/L, found in Umburanas locale to maximum values of 495.7 mg/L, Taken in the town of Mozondó. The mean concentration was 98.01 mg/L and the median 68.00 mg/L. In the towns of Coqueiro, Celestino, Mozondó and Novo Horizon were found values chlorides higher than 250 mg/L established by Brasilian MH Decree n°. 2914/11. The amounts of sulfates varied the minimum of 1.3 mg/L analyzed in Umburanas locale to a maximum of around 342.5 mg/L found locality of Maracujá. The mean and median were respectively 56.78 mg/L to 40.00 mg/L. Fluoride values were observed with minimal levels around 0.05 mg/L, analyzed in the village of Curral das Varas and reach the maximum of 8.8 mg/L measured in water from the well to the village of Mozondó (Table 2). The figure 2 shows the fluoride distribution map in groundwater of Santana région. The mean and median values of fluoride concentrations were 1.71 mg/L and 0.64 mg/L respectively,

Discussions

As for nitrate levels, according FEITOSA et al. (1979), despite the value established by the ordinance 2914/2011's Brasilian Ministry of Health to be 10 mg/L, the NO_3 levels above 5.0 mg/L may be indicative contamination by human activity. According to WHO (2004) high N-nitrate concentrations may produce poisoning in children and in extreme cases even lead her to death by methemoglobinemia (cyanosis). The development of methemoglobinemia, nitrate from drinking water depends bacterial conversion of nitrite during digestion, which may occur in the saliva and in the gastrointestinal tract. Children, particularly smaller than 3 months old, are quite susceptible to the development of this disease due to the more alkaline conditions of their gastrointestinal system. The nitrate-N also has an action in the production of nitrosamines and nitrosamides in the stomach of m ale, these substances are carcinogens (WHO, 2004).

Nitrite is a new indicator of pollution by organic matter, and when it is present in the human consumption of water has a faster and more pronounced effect than the nitrate. If nitrite is ingested directly, can cause methemoglobinemia, regardless of age user FEITOSA et al. (1979).

The high levels of chlorides that may be due to low circulation of these waters in the aquifer, as well as occurrence of a rock capable of providing such ions (Gonçalves, 2014). The mean and median for chlorides in the region are sufficient to disregard contamination of anthropogenic pathways for organe-chlorinated. Sulfates lift values in groundwater can be explained, according CUSTODY & LLAMAS (1976) by leaching formed land in large dry climate or marine environments, sulfide oxidation of pre-existing rocks, rain water, industrial and agricultural activities and concentrations evaporite. In the region in specific, according to GONÇALVES (2014) high values are suggestive of oxidizing sulfide minerals, mainly pyrite.

The fluorides and sulfates have high negative correlation and the calcium sulfide are released by the weathering of carbonate rocks, providing Ca^{+} that will interfere with the dissolution mechanism of fluorite. Using equation suggested by GALAGAN & VERMILLION (1957) it was possible to determine the value of F 0.78 mg/L as optimum content being used as a reference for the region, however what is observed for anomalous areas are numerous fluoride (Figure n). Of the 56 localities where hydrochemical data for fluoride were obtained, 25 are above the optimal value calculated, representing almost 45% of localities sampled (Table 2).

Prevalence and Severity of Fluorosis Dental

With the acquiescence of the Secretary of the Municipality of Santana Education and following the rules of the ethics committee, ten schools were visited and evaluated by a dentist/geologist, co-author of this article. The details of this survey have been presented by COUTINHO (2014). The methodology applied had the numerical universe of 159 students, randomly selected, whether they belong to 39 different locations, for which 17% reside in the municipal seat and 83% in other locations. The epidemiological survey was based on Dean index pregonizado WTO dental fluorosis. The results of Santana showed a prevalence of 53% and 35% for female and 18% male (Table 4). The discrepancy between the figures reflects the most sampled female population. It happened that during the interview process and clinical examination in almost all locations, the male youth were less likely to be examined by setting a bias to obtain the sample. Detailed documentation and photographs of this study were presented by COUTINHO (2014).

The cases produced by fluoridated water supplies, come to vary from zero (Campos et al., 1998) to 97.6% (Capella et al. 1989), according to the region. In the rural area of the municipality of Santana, where water consumption is practically limited to underground sources, the prevalence of dental fluorosis found for the age group of 12 years is well above the average prevalence in the country, which is of order 16, 3%. Regarding the severity was observed in 17.7% degree of moderate to severe, 13.8% in mild, 18% in very mild and 45% with no degree of fluorosis (Table 4).

OLIVEIRA (2014) mentions the fact of occurrence of fluorosis from various sources, resulting from consumption of food intake and dentifrices. Even if fluoride is present in the public water supply, within the standard considered optimal (0.7 ppm in Brazil), around 10% of the population will develop dental fluorosis in a clinically acceptable level. On the other hand, if the fluorine concentration exceeds the "great", the intensity of fluorosis increases, reaching levels that affect the appearance and / or function of the teeth (CURY 1992). To the municipality of Santana, COUTINHO (2014) established great value calculated was 0.78 F mg/L.

In a total of 39 evaluated localities, 14 had fluoride levels in the water, above the optimal value (0.78 mg/L) which is a risk factor for more severe impairment of teeth, affecting dental aesthetics, as can be observed in the severity of conditions under Dean classification: between 4 and 5 (moderate/severe).

According to LARSEN et al. (1985) the prevalence and severity of dental fluorosis in a population reflect the same degree as was exposed to fluoride during the calcification of permanent teeth and crowns of the period of highest risk for the development of fluorosis is first 6 years of age. The youth population evaluated in this study was born in 2002 and only in 2008 the SIAA was created when these young people had an average of 6 years of age. During this time, virtually the entire population of young people, Santana, used as a single resource, the water from underground sources, which may justify the high prevalence occurring in almost every county locations.

In appropriate proportions relative population samples obtained from epidemiological interview, the Pedra Preta locations, Sossego and Caracol showed prevalence and severity of dental fluorosis in the degrees of moderate to severe in 100% and in the towns of Barreiro Fundo, Jacaré, Tapera and the Várzea do Mourão 100% prevalence and severity (moderate to severe level) ranging from 0 to 50% These ratios are indicative of a positive correlation between existing fluoride levels and prevalence.

At the headquarters of the county and the town of Tapera, despite high fluoride levels, compared with the optimum value for the region, were not detected degrees of severity between 4 and 5 (moderate/severe). Despite the wells that fueled the county seat for a long time (before implementation of SIAA), with mean content with water F mg 1.24/L, the severity and prevalence are compatible with the values found in BRAZIL (2010) for the country (16.3%).

This fact can be explained as related by CODEVASF (1989) and by residents who, in most locations, groundwater have unpleasant taste, with brackish aspect, causing much of the population has a preference for the use of water Corrente River carried by trucks kites.

In the specific case of the municipal headquarters STD parameter (total dissolved solids) may have been the protection factor stops dental fluorosis especially for this town, whose resident population apparently has higher per capita income to those who reside in rural areas, thus being able to use other types of waters for human consumption, such as mineral water industrialized. While most rural areas, the resident population is virtually obliged to use these waters, regardless of taste.

Final Considerations

By hydrochemical analysis of Santana water for nitrates, sulfates and chlorides are evident that there is no addition of fluoride derived from fertilizers or other Organos chlorinated that may contribute to the significant increase in values of this element in groundwater. Only Gameleira locality was found nitrate content of 5.6 mg/L, which are suggestive of a small sewage contamination.

Dental fluorosis in children 12 years old is a public health problem in Santana region, considering the high prevalence in almost 53% of the evaluated young people, and has presented severity of 17.7% (moderate to severe) at odds with the values obtained in the BRAZIL (2010) for dental fluorosis in Brazil, the same age group, who have prevalence rate of 16.3% and almost no degree of severity.

In the municipality of Santana, Bahia, the percentage 53% prevalence of 17.7% of severity (moderate / severe) confirms the hypothesis of contamination through consumption of natural source of water. For as CANGUSSU op. cit. (2002) the high prevalence of dental fluorosis in people with moderate and severe forms is still small in the world only significantly increases the places where fluorosis is produced by high concentrations of fluoride from natural water sources. This hypothesis can be proven by the positive correlations between fluoride levels in groundwater Santana-BA and prevalence/severity of dental fluorosis.

Of the total 39 localities raised as place of residence and consumption of water for the population of interest in this research, the number of 14 locations are inserted in the high risk area susceptible to dental fluorosis since the fluoride levels in water show values higher than the amount calculated great (0.78 mg/L). The locations are as follows: Baraúnas, Barreiro Fundo, Queda d´água, Canabrava, Jacarér, Pedra Preta, Sossego, Santana Municipal Office, Tamboril, Caracol, Tapera, Várzea do Mourão.

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Table 1 - Children residing in the municipality of Santana - Bahia in 2010

Age	Children / teens	Percentage	Accumulated percentage
1	395	4,6	4,6
2	352	4,1	8,6
3	364	4,2	12,8
4	435	5,0	17,9
5	390	4,5	22,4
6	402	4,6	27,0
7	359	4,1	31,2
8	489	5,7	36,8
9	529	6,1	42,9
10	522	6,0	49,0
11	452	5,2	54,2
12	423	4,9	59,1
13	481	5,6	64,6
14	548	6,3	71,0
15	508	5,9	76,8
16	513	5,9	82,7
17	539	6,2	89,0
18	475	5,5	94,5
19	479	5,5	100,0
Total	8.654	100,0	

Source: IBGE (2010) .

Figure 1 – The Santana municipality is located 813 km from Salvador, in the southwest of Bahia, Brazil.

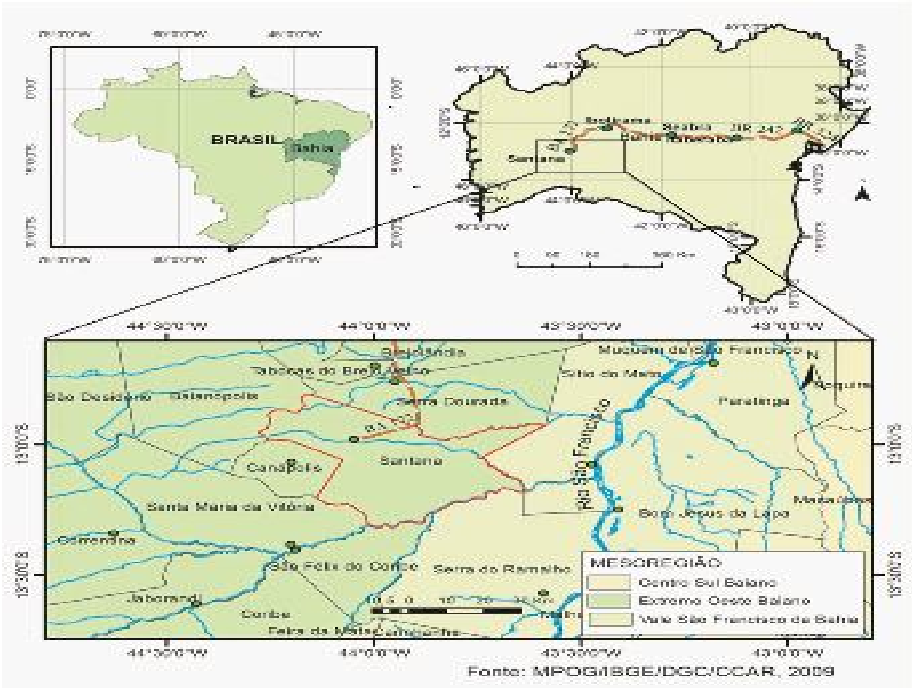

Figure 2 – The Fluoride distribution map in groundwater in the municipality Santana: risk areas with the incidence of dental fluorosis.

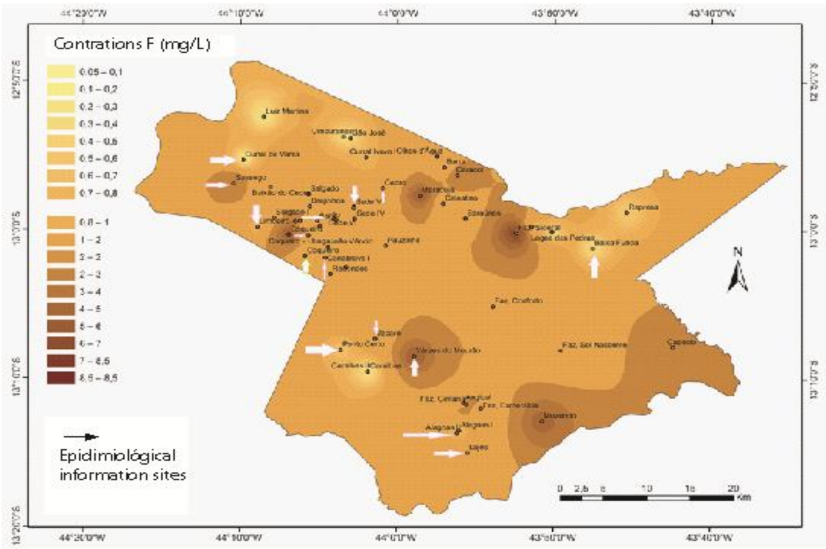

Table 2 - Physicochemical data, major elements of groundwater Santana. Available in SIAGAS and Gonçalves (2014).

Site	N/S	E/W	pH	Cl-	SO42-	NO3-	F-	Refe.
Alagoas I	8537731	615572	8.30	53.4	86.00	0.46	0.54	SIAGAS
Alagoas II	8537425	615331	7.40	158.9	91.00	1.82	0.97	SIAGAS
Angical	8541170	616099	7.30	47.1	41.00	0.46	0.34	SIAGAS
Areão	8563811	599276	8.15	104.30	25.35	0.13	3.25	Gonçalves
B. Funda	8560306	630972	7.10	40.3	46.00	0.86	0.34	SIAGAS
B. do Cedro	8567984	593883	7.62	45.56	47.93	1.14	0.27	Gonçalves
Baraúnas	8564028	616316	8.30	98.3	50.00	1.49	1.25	SIAGAS
Barra	8570398	613932	7.10	29.6	47.00	0.46	0.57	SIAGAS
Brejinhos	8565540	598393	7.65	87.60	75.43	0.92	0.94	Gonçalves
Caboclo	8548001	640218	8.30	53.4	27.60	0.46	2.93	SIAGAS
Canabrava	8559145	600179	7.60	68.0	29.80	0.06	1.88	SIAGAS
Caracol	8569377	615435	8.11	140.30	40.97	0.53	3.11	Gonçalves
Caracol I	8569377	615435	8.60	125.9	32.80	0.46	3,8	
Caraíbas	8545055	605095	7.20	45.4	29.60	0.46	0.25	SIAGAS
Caraíbas II	8545086	605095	8.36	126.9	32.80	0.45	0.31	SIAGAS
Cedro	8567784	606810	7.64	83.60	64.61	2.90	0.31	Gonçalves
Celestino	8565881	613763	8.30	257.4	176.0	1.42	0.75	SIAGAS
Coqueiro	8562048	595972	8.50	422.1	22.80	0.46	7.50	SIAGAS
Coq-Utinga	8561978	598202	7.26	125.30	85.53	0.17	0.40	SIAGAS
C. Varas	8571313	590761	7.88	25.8	26.00	0.66	0.05	Gonçalves
Curral Novo	8571631	604896	8.50	35.1	17.00	1.25	0.69	SIAGAS
Faz. Areão	8564000	601200	7.75	64.0	36.00	0.46	0.43	SIAGAS
Faz. Areão	8563900	601440	7.85	41.0	36.00	0.46	0.09	SIAGAS
Conforto	8553137	619492	7.20	84.8	47.00	0.46	1.26	SIAGAS
Esmeralda	8540485	618113	7.30	40.2	25.00	0.46	0.52	SIAGAS
Faz. Sideral	8562190	622183	7.96	186.9	187.5	0.46	8	SIAGAS
F. Sol Nasc	8547633	627328	7.00	22.1	21.60	0.46	0.64	SIAGAS
Gameleira	8558060	602556	7.34	141.60	65.40	5.40	0.51	Gonçalves
Jacaré	8549107	605924	7.20	40.5	15.10	0.46	1.28	SIAGAS
J. Vêncio	8560495	600515	8.36	5.8	10.90	0.46	1.08	SIAGAS
L. Pedras	8562386	626281	7.27	52.5	61.90	1.18	0.29	SIAGAS
Lajes	8534962	616523	7.20	48.2	16.00	0.46	1.72	SIAGAS
Limoeiro	8563012	592390	8.20	46.7	36.00	0.09	0.54	SIAGAS
L. Martins	8576650	593129	8.43	7.0	9.44	0.03	0.22	SIAGAS
Maracujá	8566875	611085	8.80	183.4	342.5	0.46	5.45	SIAGAS
Mozondó	8538887	625119	8.60	495.7	167.5	0.46	3,05	SIAGAS
Nova Glória	8565500	603500	7.60	11.0	36.00	0.46	0.13	SIAGAS
Novo Hor.	8563011	623964	8.30	259.6	185.0	0.46	0.36	SIAGAS
Ol. d'Água	8571722	613063	8.80	84.6	135.0	0.25	2.10	SIAGAS
P. de Exp.	8565308	603486	7.95	45.0	28.60	0.46	0.19	SIAGAS

Pauzinho	8560654	607144	8.30	15.6	11.40	0.46	2.56	SIAGAS
Pedra Preta	8563669	596733	8.93	170.20	15.00	0.81	4.65	Gonçalves
Pedra Preta	8563732	597304	7.69	142.30	60.75	1.17	0.14	Gonçalves
Ponto Certo	8547740	601944	7.53	95.69	68.65	0.04	0.55	Gonçalves
Ponto Certo	8547740	601944	7.70	75.0	52.80	0.09	0.51	SIAGAS
Redondos	8557145	600774	8.30	46.2	10.00	0.50	1.50	SIAGAS
Represa	8564742	634910	7.20	120.7	82.00	0.46	0.49	SIAGAS
Salgado	8567047	598249	7.51	40.39	53.74	0.19	0.36	Gonçalves
São José	8573972	603126	8.30	54.8	65.00	0.46	0.38	SIAGAS
Sede IV	8563986	603571	7.80	58.0	27.00	0.46	1.68	SIAGAS
Sede V	8565400	603486	7.60	124.0	31.40	0.04	1.71	SIAGAS
Sede VI	8564213	600378	7.55	92.5	84.00	0.46	0.33	SIAGAS
Sossego	8568424	589647	8.70	76.23	10.57	0.37	3.50	Gonçalves
Umburanas	8574160	602283	7.70	5.3	1.30	0.46	0.33	SIAGAS
V. Mourão	8546969	610402	8.65	85.00	45.00	0.56	5.04	Gonçalves
V. Mourão	8546969	610402	8.78	49.6	40.00	0.46	8,8	SIAGAS
minimum			7	5,3	1,3	0,03	0,05	
maximum			8,93	495,7	342,5	5,4	8,8	
average			7,92	98,01	56,78	0,66	1,71	
median			7,85	68	40	0,46	0,64	
Standard Deviation			0,55	94,44	58,07	0,8	2,1	
Standard Error			0,07	12,51	7,69	0,11	0,28	
Coefficient of variation (%)			6,94	96,35	102,3	121	125	

Table 3 - Physical and chemical analysis, key elements carried in groundwater collected in Santana-BA, Gonçalves (2014)..

		UTM			mV	μS.cm-1	mg.L-1										
Well	Locality	N/S	E/W	pH	ORP	CE	STD	Na+	K+	Ca2+	Mg2+	Cl-	HCO3-	SO4 2-	NO2—N	NO3--N	F-
P1	Ponto Certo	8547740	601944	7.53	62.00	845.00	549.30	20.32	2.14	135.00	14.43	95.69	255.00	68.65	0.03	0.04	0.55
P2	Lagoa das Pedras	8562386	626281	7.27	-32.00	743.10	483.00	20.45	2.70	197.27	13.50	67.59	260.00	72.09	0.04	1.16	0.23
P3	Cedro	8567784	606810	7.64	147.00	905.00	578.00	32.72	1.30	107.50	13.94	83.60	225.50	64.61	0.01	2.90	0.31
P4	Salgado	8567047	598249	7.51	75.00	709.00	454.00	18.80	1.80	93.21	14.89	40.39	250.70	53.74	0.05	0.19	0.36
P5	Baixão do Cedro	8567984	593883	7.62	117.00	717.00	459.00	19.03	1.56	98.49	11.93	45.56	245.10	47.93	0.02	1.14	0.27

P6	Coqueiro - Utinga	8561978	598202	7.26	123.00	1060.00	681.00	24.74	1.83	144.00	16.86	125.30	225.20	85.53	0.02	0.17	0.40
P7	Gameleira	8558060	602556	7.34	76.00	1050.00	674.00	34.56	4.50	115.40	14.51	141.60	184.00	65.40	0.02	5.40	0.51
P8	Pedra Preta II	8563732	597304	7.69	19.00	1129.20	734.00	35.96	2.86	96.98	14.05	142.30	178.00	60.75	0.13	1.17	0.14
P9	Brejinhos	8565540	598393	7.65	-27.00	918.50	597.00	60.34	2.08	83.32	13.71	87.60	232.50	75.43	0.03	0.92	0.94
P10	Caracol	8569377	615435	8.11	-216.00	807.00	516.00	145.11	3.06	22.83	11.37	140.30	205.00	40.97	0.01	0.53	3.11
P11	Areão	8563811	599276	8.15	-184.00	1090.00	699.00	144.96	2.98	10.55	3.68	104.30	250.10	25.35	0.05	0.13	3.25
P12	Coqueiro	8562048	595972	8.72	-181.00	1730.00	1110.00	238.30	5.21	20.65	10.21	300.50	246.30	20.29	0.04	0.35	6.20
P13	Várzea do Mourão	8546969	610402	8.65	-163.00	1081.00	702.10	207.15	3.21	16.00	1.22	85.00	366.00	45.00	0.02	0.56	5.04
P14	Sossego	8568424	589647	8.70	-65.00	688.00	440.00	95.65	2.47	18.14	3.78	76.23	202.30	10.57	0.04	0.37	3.50
P15	Pedra Preta I	8563669	596733	8.93	31.00	1100.00	701.00	177.65	2.71	5.45	3.09	170.20	198.10	15.00	0.23	0.81	4.65
VMP by Decree 2,914 / 2011 or WHO (2003)				-	-	-	1000.00	200.00	-	75.00	50.00	250.00	-	250.00	1.00	10.00	1.50
Determination Workable range (CONAMA 396/2008)				-	-	-	-	0.01	0.005	0.01	0.01	0.01	-	0.01	0.005	0.01	0.01
minimum				7.20	-216.00	688.00	440.00	18.80	1.30	5.45	1.22	40.39	178.00	10.57	0.01	0.04	0.14
maximum				8.93	147.00	17.30	1110.00	238.30	5.21	197.27	16.86	300.50	366.00	85.53	0.23	5.40	6.20
average				7.92	-14.53	971.00	625.16	85.05	2.69	77.65	10.74	113.74	234.92	50.09	0.05	1.06	1.96
median				7.65	19.00	918.00	597.00	35.96	2.70	93.21	13.50	95.69	232.50	53.74	0.03	0.56	0.55
Standard Deviation				0.58	122.37	263.66	169.37	77.15	1.06	58.99	5.14	63.75	44.93	23.46	0.058	1.40	2.10
Standard Error				0.15	31.60	68.08	43.73	19.92	0.27	15.23	1.33	16.46	11.60	6.06	0.01	0.36	0.54

Coefficient of variation (%)	7.32	842.00	27.14	27.09	90.71	39.20	75.96	47.82	56.05	19.13	46.84	117.06	132.23	107.21
P value (Shapiro- Wilk normality test)	0.037	0.1945	0.0099	0.0109	0.0098	0.1533	0.1258	0.0099	0.0102	0.0123	0.4394	0.0075	0.0080	0.0096

Table 4 - Epidemiological study summary based on the Dean index.

Places	Content of Fluoride (mg / L)	Prevalence (%)	moderate to severe (%)	Total Individuals
Alagoas	0,54	20	20	5
Barreiro Fundo	1,6	100	0	3
Cachoeira	2,4	50	25	12
Canabrava	1,88	82	47	17
Cedro	0,31	0	0	3
Jacaré	1,28	100	25	4
Limoeiro	0,54	7,7	0	13
Pedra Preta	4,65	100	100	8
Ponto Certo	0,55	33	0	6
Porto Novo	0,8	10	0	10
Sossego	3,5	100	100	2
Sede	1,24	26	0	27
Tamboril	1,8	50	50	4
Caracol	3,8	100	100	1
Tapera	1,9	100	0	4
Vázea do Mourão	5,04	100	50	5
Other places **	*0,54	10	0,6	35
Total individuals				159
* average content of fluoride , ** 24 location			Total	39