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# GROUNDWATER QUALITY IN COAST REGION, PIAUI STATE, BRAZIL

**CLARICE M. LEAL[1], ADERSON S. ANDRADE JÚNIOR[2], VALDEMÍCIO F. SOUSA[2], ÊNIO F. F. SILVA[3], EDSON A. BASTOS[2]**

[1] Graduate Student, Biologic Science, Scholarship holder IC/FUNCAMP, Embrapa Middle-North, Teresina, PI, clarice@cpamn.embrapa.br
[2] Agronomist, PhD, Reseacher, Embrapa Middle-North,Teresina, PI.
[3] Agricultural Eng., Assistant Professor, Universidade Federal Rural de Pernambuco, Recife, PE.

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**ABSTRACT:** The water resource systems of the coastal region of the Piaui State, Brazil, are abundant and of high productivity, favoring the use of the underground water for several ends such as, human consumption, irrigation and local tourism. Problems caused by the inadequate handling of the soil and the utilization of unsafe wells, are some of the factors that contribute, directly or indirectly, to the maintenance of the environmental quality of these resources. This study aimed to obtain current information on the physical and chemical characteristics to evaluate the underground water quality in six locations of the coastal region. Samples of 54 public and private wells were collected during the 2004 and 2005 dry season. The results were interpolated in geographical information system (GIS). It was concluded that the north and east costal region were the ones that presented the highest salinity indexes, presenting great restrictions to human consumption and irrigation.

**KEYWORDS:** salinity, irrigation, human consumption.

**INTRODUCTION:** The coastal region of Piauí State, Brazil, is characterized by the presence of a wide variety of bodies of water and waterways such as rivers, bays, ponds, swamps and irrigation channels that contribute for maintenance of important water resources in the area. The sedimentary nature of the Parnaíba river basin propitiates the formation of high productivity aquifers, favoring the perforation of wells for several ends, including supply water to communities, industries, and farms. It also helps the tourist industry, providing water for hotels, tourist resorts and holiday condominiums. REBOUÇAS (2002) points out that the use of underground water has become a wide spread practice in the last decades, mainly for being a low cost solution. It dispenses additional treatments to several sectors, of the most different climatic regions of the planet. According to the author, it is a disturbing fact, due to the lack of control, for the benefit of its use and protection. The problem of aquifers contamination by saline intrusion may be observed in coastal areas. According to MESTRINHO (2008), the growing number of tubular wells perforated in coastal areas group to a hydrodynamic unbalance, since it raises the reduction of the fresh water discharge into the sea, fact this that provides a mixture among sweet and salted water. Under this aspect, is important a study regarding the groundwater quality in coastal areas, because they are complex ecosystems, subjects to the different impacts. This work had as objective accomplishes a rising of the groundwater quality in six different locations of the coast region, through the determination of important physical and chemical parameters for human consumption and irrigation.

**METHODOLOGY:** The study area is located among the 02º43'42"S and 03º22'59"S latitudes and 41°14'23"W and 41°59'11"W longitudes, including six municipal districts of the coast region, Piauí State, Brazil. The climate, according to the Köeppen is Aw', tropical rainy. The average annual precipitation is 965 mm, with the rainy period from January to June (BASTOS et al., 2000). The data base of public and private wells registered by the Geological Service of Brazil – CPRM was used. The chosen wells were georreferenced. Two samplings were taken one in 2004 dry season (E1) and other in 2005 dry season (E2), in 54 public and private wells. The total dissolved solids (TDS), electric conductivity (EC) and pH were determined, in field, using a water quality probe, model YSI 6600. The other variables as calcium (Ca), magnesium (Mg), sodium (Na), chloride (Cl), bicarbonate (HCO3) and carbonate (CO3) were evaluated in the Laboratory of Water and Soil of Embrapa Middle-North, according to EMBRAPA (1997). The static and dynamic levels, through the use of electronic meters, were measured. The results were tabulated and starting from the coordinates of the wells was incorporating a geographical information system (GIS/Spring). A rectangular grating was generated starting from the points and was used the average meditated interpolator. It was applied the bicubic interpolator for the refinement of each grating. The thematic maps were constituted through the sliced in classes of use restriction for the human consumption, according to the recommendations of CONAMA (Res. 357/2005), MINISTÉRIO DA SAÚDE (Port. 518/2004) and for the irrigation in agreement with AYERS & WESTCOT (1991).

**RESULTS AND DISCUSSION:** In the E1, it was verified that 69.23% of the static and dynamic levels were below 20 meters. Similar fact happened during E2, when 80.39% of the static levels were lower than 20 meters, 11.7% of the levels were between 20 and 50 meters, and only 7.84% presented values above 50 meters. Regarding the pH, the occurrence of neutral to alkaline waters was verified in E1. Acids values were registered mainly in Bom Princípio do Piauí, Luís Correia and Buriti dos Lopes, in both seasons, besides the central and north portion of the Parnaiba municipal district, during E2. Most of the samples were inside the acceptable limits for the human consumption and for irrigation (pH between 6 and 9) (CONAMA, 2005), not representing high risks. However, the salinity parameters showed values that surpassed the advisable limits for irrigation and the human consumption, in most of the municipal districts. The values of Cl varied from 1.05 to 19.87 mmolc $L^{-1}$ (E1) and from 1.22 to 83.6 mmolc $L^{-1}$ (E2), and only Buriti dos Lopes municipal district, in the two seasons showed values lower than the irrigation pattern (< 3.0 mmolc $L^{-1}$). Accentuated restrictions for the human consumption were observed, mainly, in the central and east portion (E2), and Parnaíba, Luís Correia, Bom Princípio do Piauí and Cajueiro da Praia showed values above the maximum allowed limit. These areas also presented moderate restrictions for sprinkler irrigation (> 3.0 mmolc $L^{-1}$), in relation to Na (E1), besides the north of Parnaíba and Luís Correia. In E2, the restrictions to this irrigation type concentrated at Luís Correia, Bom Princípio do Piauí and Ilha Grande. It is still pointed out, that, the surface irrigation should be applied with caution in Luís Correia, because values above 9 mmolc $L^{-1}$ were obtained in this municipal district, value what characterizes a severe restriction to this use. AYERS & WESTCOT (1991) affirm that water with high level of sodium can provoke burns of the leaves in the sprinkler irrigation. The use of this water in surface irrigation can cause the reduction in the soil permeability. Regarding the human consumption, the values surpassed the recommendations (200 mg $L^{-1}$) (MINISTÉRIO DA SAÚDE, 2004), mainly during E2, in the Luís Correia, Bom Princípio do Piauí and Cajueiro da Praia. It was verified, still, a correspondence among the tendencies presented by the EC maps and the results visualized in Cl maps, standing out the north and east portions as the ones that presented the highest salinity indexes, as can observe in the Figure 1. These results agree with observations of PIVELI (1998), when it places that the saline intrusion has important effect on the groundwater water quality in the coastal areas. Another factor that could explain the occurrence of water with high levels of salts in the east portion of the area would be the presence of crystalline rocks, as verified by CPRM (2008).

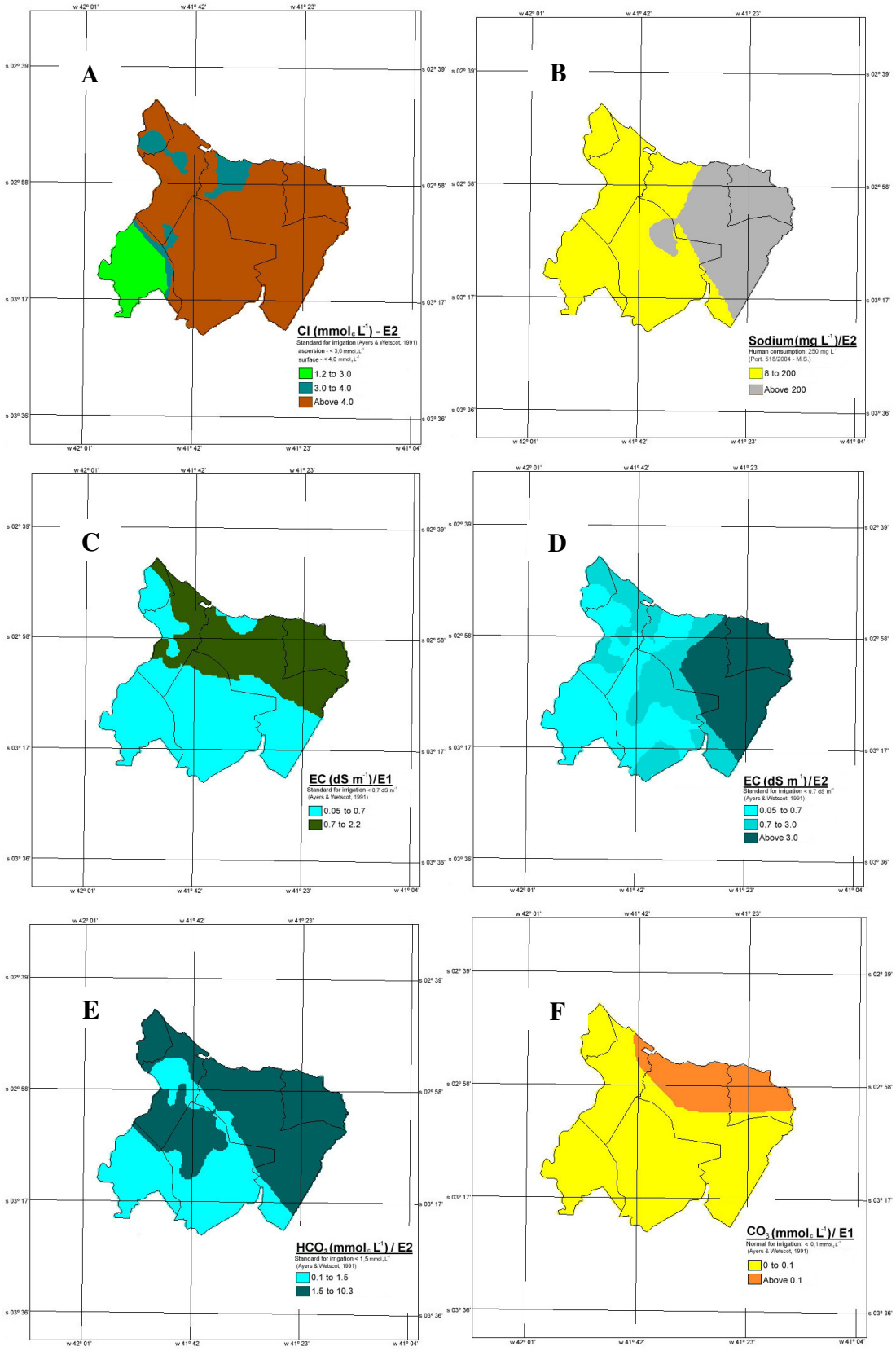


**FIGURE 1.** Chloride (A), sodium (B), electric conductivity (C and D), bicarbonate (E) and carbonate (F) maps in collection seasons (E1 and E2).

The most significant results for the TDS restrictions agree with the EC analysis, being the north and east portions with the highest values. The north of the Luís Correia, Parnaíba, Cajueiro da Praia and Bom Princípio showed values above the maximum limit allowed for irrigation (450 mg $L^{-1}$) and human consumption (500 mg $L^{-1}$) (CONAMA, 2005). In agreement with PIVELI (1998), TDS are constituted in potability parameter, once they correspond to the levels of salts as chloride, sulfate, carbonate, among other presents in the water, linking directly with the electric conductivity. In general, the cations (Ca and Mg) presented normal values for irrigation (< 20 $mmol_c$ $L^{-1}$ for Ca and < 5 $mmol_c$ $L^{-1}$, for Mg), in both seasons, being pointed out, only, the verification of quick restrictions to Mg, in east portion (E2), mainly in Luís Correia and Cajueiro da Praia. For the human consumption, the effective legislations don't designate limits, being considered parameters without risks to the human health. For the anions $CO_3$ and $HCO_3$, the restrictions for irrigation were concentrated mainly at the coastal and east area (Figure 1E and F). Bom Princípio do Piauí, Buriti dos Lopes and Parnaíba showed, also, surpluses values for $HCO_3$ (E2). The most significant results of $CO_3$ for irrigation, came in the Parnaíba, Cajueiro da Praia and Luís Correia, with values above the allowed maximum limit (0.1 $mmol_c$ $L^{-1}$) (E1). The evaluation of the $HCO_3$ and $CO_3$ levels in irrigation water becomes important, once in excess, these ions can provoke the calcium precipitation, what elevates the risk of soil sodicity (AYERS & WESTCOT, 1991). For the human consumption, the effective legislations don't foresee risks to the population health regarding the analyzed elements.

**CONCLUSIONS:** In the Piaui State costal region, the north and east portions were the ones more reached by the high salinity index, representing the areas of larger restrictions to the water use for the human consumption and irrigation.

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