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SURVEY AND CARTOGRAPHY OF THE SPATIAL VARIATION OF THE POLLUTION OF THE WATERS FROM WELL OF SOME DISTRICTS OF THE TOWNSHIP OF ABOMEY-CALAVI, BENIN.

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ABSTRACT: *The right to the development and to the improvement of the setting of life of each one as well as the duty to protect natural heritage are nowadays two (02) parameters, of a difficult problem to approach (AMHARREF and BERNOUSSI 2007). So, the water that constitutes a primordial factor for the human life and for all economic development is contaminated often by anthropic activities. The situation is more critical for the under-developed countries with limited water resources; it is the case of Benin. The major question that puts itself is then how to manage, to decontaminate and to protect our water resources without breaking down the anthropic activities affecting economic growth? This situation calls for protective and preventative measures that cannot be optional. The nature and the size of the measures to be taken according to the zones require a very advanced knowledge of features of these waters and the sources of their pollution. A prospective survey of three months spread from the month of January in the month of March 2013 and having for objective the assessment and the cartography of the hygienic quality of the waters of wells used like drinking water and also for the domestic activities, by the population of some districts of the township of Abomey-Calavi, has been achieved. To the total, twenty (20) withdrawals of water have been done from some twenty (20) wells presenting risks for the health of their users. The bacteriological analysis showed that all waters of well reveal a pollution due to the bacteria as the coliforms thermotolerants, the intestinal enterococcus, the total coliforms with the most elevated concentrations in the wells situated very close to the Lake Nokoué. It reveals that these waters can be responsible for the dissemination of water related diseases. The report between the coliforms' thermolerants and the intestinal enterococcus indicated that the origin of the fecal contamination is of human type in 50% of the wells. The fecal contamination of human type concerns all wells close to the lake and the one of animal type concerns wells moved away of this lake.*

KEYWORDS: Water of Well, Pollution, Cartography, Nigeria, Water Resources.

INTRODUCTION

The water resources of the earth are enormous but limited. Atmospheric pollution is at the origin of the destruction of the ozone layer and the last is at the origin of the climatic warming up that has disastrous effects. Among other, the climatic warming up dries out water from (lakes, lagoons, streams…). Therefore, resources in soft water rarefy progressively. Or is also polluted, water is the gas of life (Abdel, 2001). As oil in our days, water risks to become therefore a fundamental stake in the future. Water could become during the next century, the stake of large

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scale commercial and geopolitical conflicts and therefore, it can cause the 3rd world war (Monjour 1997).

Nowadays, the problem of water is already critical in the under developed countries where very little people have access to drinking water. In Benin, because of the insufficient financial means, a large majority of the population (65% about) didn't register with the National Water Corporation (AGASSOUNON TCHIBOZO and al 2010). This population consumes waters of well in general without a previous treatment and is exposed to numerous diseases. In the township of Abomey-Calavi (South - Benin), during the rainy season, several people are affected by water related diseases of which cholera, that is provoking some deaths. The population of the township of Abomey-Calavi essentially consumes underground water from traditional wells and (or filtered water treated and delivered by the SONEB). This underground water deserves a particular attention then. The recrudescence of the illnesses related to water during the season of rains testifies the acquirement of the pollutants by the underground waters from the waters of rains and the waters of surface. Prevention is the best cure and one cannot prevent a pain without having diagnosed it and so possible after having clarified the mechanism through which this pain occurs. The diagnostic of the acquirement of the pollutants by the underground waters in the township of Abomey-Calavi is especially important, the underground waters of the township of Abomey-Calavi are the most exploited of Benin. These waters are appropriated, treated and used by the SONEB to serve drinking water to the population of the township of Abomey-Calavi, Cotonou (biggest of Benin) and the city of Sèmè. The population of Abomey-Calavi essentially consumes the underground waters from the traditional wells and drilling (adduction of water villager and waters of boring treated and stake at the disposal of the population by the SONEB).

It is therefore judicious to do the present study under the title: "Methodology and diagnostic of the acquisition of the pollutants by the underground waters from the rainwaters and the waters of surface in the township of Abomey-Calavi (south Benin)".

This work is a very important tool to undertake an efficient remedy of the pollution of these waters. Indeed, this work permits us to study and to map out the spatial variation of the pollution of the waters of well of some districts of the township of Abomey-Calavi. It permits to identify the sources and the size of the pollution according to the zones and to consider some remedies.

MATERIALS AND METHODS

Presentation of the Survey Zone

Abomey-Calavi is a Beninese city, situated in the department of the Atlantic (South - Benin). The city spreads on a surface of 650 km² and account 307,745 inhabitants since the last census of the population of 2002.

Surrounded by the townships of Sô-Ava, Bopa and Tori-Bossito, Abomey-Calavi is located 13km Northwest of Cotonou the economic capital of Benin. Situated at 12 km of altitude, the city of Abomey-Calavi has for geographical parameters 6°27'0 North and 2°21'0 East. The township of Abomey-Calavi today is subject to the influence of the proximity of Cotonou. Indeed, the narrowness of the site of Cotonou and strong population drives to an extension toward Abomey-Calavi.

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The most important waters that cross the township of Abomey-Calavi are the lagoon of Djonou and the Nokoué lake.

The biggest part of the territory of the Township of Abomey-Calavi is occupied little by the tropical ferruginous soils and the gritty soils auspicious to agriculture. Hydromorphic and liable to flooding soil occupy a part of the north of the territory. The arable earths are estimated at 465.5 km². The plant table setting of the township varies according to the crossed feature. Thus, one meets of it the mangrove swamp to mangroves in the inshore zone, a savanna damaged on the tray, of the market cultures along the swamps, a grassy grouping in the marshes and along the banks of the Nokoué lake.

The township of Abomey-Calavi is situated in the intertropical zone. In this zone, the climate is of subequatorial type characterized by two (02) seasons of rains (of September to November and March to July) and two (02) dry seasons (of November to March and July to September).

The township spreads on two (02) big geological formation types. The quaternary formations that are sandy deposits of the coastal cord, of the lagoon deposits makes of clay and sand and deposits constituted alluvium of sand and clay. The tertiary formations as for them are essentially constituted of clay and sand.

Sampling

The township of Abomey-Calavi is a township of Benin in which water from wells is essentially used (the traditional wells and the boring). Water of drilling type is relatively of good quality. Water from traditional wells of the township of Abomey-Calavi are all polluted (BOSSOU 2002, DEGBEY, 2004, HOUNSINOU, 2012). The township of Abomey-Calavi counts nine (09) districts of which the district of Abomey-Calav is the less equipped with drills. In the precinct of Abomey-Calavi on average, there is a traditional well by house. The waters of these wells are all polluted. In particular those that are close to the Nokoué lake are the most vulnerable. Indeed, these last are of weak depths (20 m about) and are exposed to the fecal pollution especially by the septic pits and by the waters of infiltration. Twenty (20) representative samples of these wells are the object of the present survey.

CARTOGRAPHY AND DOSAGE

The particulars of the wells have been used to achieve the cards of distribution of the wells with the help of the software Area view 3.2.

During our survey on the field, (January to March 2013), the physical and chemical parameters (pH, temperature, dissolved oxygen, conductivity, dissolved salt) have been measured in situ. The samples of waters intended to the chemical analyses have been appropriated in clean covered plastic bottles, which were previously labeled.

The withdrawals of waters intended to the microbiological analysis in the wells have been achieved with the help of the sterilized small bottles labeled previously, attached each by a thread clean to the tip of which is fixed a stone. It permits to prefer to about 50 cm of the surface free of water contained in the well. Once full of water, the small bottles were pulled back up from the wells, closed and placed in the icebox which is planned to contain them. It is placed there among ice pieces so that the microbiological parameters are not modify because of the

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temperature variations. Then the samples are transported to the laboratory so that microbiological analysis can be performed.

According to the physical and chemical parameters to measure where the ions to measure out different methods, described in the chemistry general works, have been used.

The temperature, the pH, the dissolved oxygen, the rate of oxygen saturation and the potential redox have been measured by a pH/oxymeter according to the norm AFNOR NF IN 25814.

The saltiness, the conductivity and the TDS have been measured by conductivity.

The turbidity is measured by colorimeter.

Lead and zinc are measured out by spectrophotometry.

The microbiological parameters (Escherichia coli, total coliforms, intestinal enterococci, coliforms thermotolerants and banal germs) have been measured according to the method by incorporation in agar-agar described in the book the Rodier.

The results of the measures of the physical and chemical parameters and the heavy metals of the waters of well are consigned in the picture 1 and the results of the measures of the microbiological parameters of the waters of well are consigned in the picture 2.

We present here the distribution of the values of these parameters in the zone of survey.

To really interpret these results, we measured the physical and chemical parameters and of the heavy metals in the waters of the Nokoué lake and in the rainwaters in the zone of survey.

RESULTS AND INTERPRETATIONS OF THE PHYSICAL AND CHEMICAL PARAMETERS AND THE HEAVY METALS pH

The pH informs on the activity or the alkalinity of a solution. The pH of the waters of surface and the underground waters is bound to the nature of the rocks crossed. The pH of the rainwater reflects the nature and the size of the air pollutants. Rain very industrialized country is acidic because of the dismissals in the atmosphere of gases as the carbon monoxide, the dioxide of carbon, the dioxide of sulfur (HOUNSINOU, 2012)…

According to instructions of the European Union on the 03/11/98 concerning the quality of water, of the pH of a water destined to the consumption must be consistent between 6.5 and 9.

The pH of the studied well waters varies from 4.3 to 7.2.

60% of the wells sampled have a pH below the lower doorstep of the norm (6.5). This acidity is probably due to the geological nature of soil. It confirms the results of BOSSOU in 2002 DEGBEY in 2004, of GOMEZ in 2009, of HAISSOUFI EL and al in 2011 and HOUNSINOU in 2012. These too acidic waters are those of the wells n°9 to the well n°20 that is relatively the most distant of the Nokoué lake.

40% of the waters of well sampled (well n°1 to the well n°8) have a pH compliant to the norms of the Union European. These wells are the nearest of the Nokoué lake. The average of the pH of these last wells (6.9) is nearly equal to the average of the pH of the samples of water of the

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Nokoué lake (6.8) and that is nearly equal to the middle pH of the rainwaters meteoroid (6.7) in the zone of survey. It is noted that Benin being poorly industrialized, the atmospheric pollution by the carbon monoxide, the dioxide of carbon and the dioxide of sulfur is very weak. It is why the pH of the rainwaters meteoroid is less acidic in the zone of survey. These are the pluvial waters that nourish the Nokoué lake that is why the waters of this lake are almost neutral as the rainwaters meteoroid. The waters of well near of the Nokoué lake come mainly from the Nokoué lake and it is why the waters of the wells n°1 to 8 are almost neutral.

The variation of the pH of the waters of well permitted to identify the wells whose pollution is susceptible influence by the waters of the Nokoué lake. It is about the wells n°1 to 8. Let's underline that the life span of the bacteria is shorter in acidic soils (pH between 3 and 5) that in the alkali soils. The pH of the wells near of the lake is more favorable to the development of the microorganisms.

Electric Conductivity

It permits to appreciate the degree of water mineralization. Its variation permits to follow the evolution of a chemical pollution (DEGBEY, 2004).

The measure of conductivity permits to value quickly but roughly the global mineralization of water. The French Law gives the following indications on the relation existing between mineralization and conductivity (Rodier, 1978; BOSSOU, 2002).

Conductivity <100 µs/cms: Very weak Mineralization.

100µs/cm <conductivity <200µs/cm: Moderate Mineralization.

200µs/cm <conductivity <333µs/cm: Strong enough Mineralization.

333µs/cm <conductivity <666µs/cm: Strong Mineralization.

666µs/cm <conductivity <1000µs/cm: Very strong mineralization.

Conductivity 1000µs/cm: Excessive Mineralization.

Water destined to consumption must have a conductivity lower than 250µs/cm (Guideline of the Union European of the 03/11/98).

60% of the studied well waters have a conductivity compliant to the norms of the European Union. The conductivity of the waters of well analyzed varies from 66.8µs/cm to 1128µs/cm. 25% of these waters have a very weak mineralization; 30% have a moderate mineralization; 20% have a strong enough mineralization, 15% have a strong mineralization, 5% have a very strong mineralization and 5% of these waters have an excessive mineralization.

All wells moved away relatively from the Nokoué Lake (well n ° 9 to 20) but the well n ° 17 have conductivity compliant to the norms of the European Union.

Most nearest wells of the lake (Well n°2, 3, 4, 5, 7 and 8) have a conductivity passing the norms of the WHO and the European Union. These last wells are polluted by the Nokoué lake that is mineralized very excessively (equal conductivity to 9000µs/cm on average). The wells near of the lake are the wells the more mineralized and less mineralized than the lake because the water of the lake very loaded of minerals nourishes these wells but at the time of the passage of the

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water of the lake toward the wells, according to the crossed rocks and the depth of the wells, the water of the lake is filtered and is ridded of a part of these minerals.

Total Solide Dissolved (TDS)

It is essentially about the strong minerals in water: calcium, magnesium, sodium, bicarbonates, chlorides and sulphates; they confer to water his/her/its taste (DEGBEY, 2004).

The TDS informs on the mineralization of a water. The saltiness of waters can also be represented by the TDS that corresponds to the sum of the concentrations of the major chemical elements (Ca^{2+}, Na, Mg, K, Cl, SO_4, NO_3, HCO_3) (GOMEZ, 2009).

The conductivity is bound to the concentration of all ions in the solution: major ions and minor ions (often the nitrites, iron, ions ammonium, fluorine, lead…). The minor elements are appreciated in relation to the weak concentration of their content in waters. The conductivity essentially depends therefore on the major chemical elements of the TDS.

Thanks to the software SPSS (Statistical Package for Social Science) we calculated the coefficient of interrelationships between the physical and chemical parameters of the waters of well analyzed.

We noted that the saltiness is bound strongly to the conductivity (0.893) and to the TDS (0.894). The TDS is perfectly bound to the conductivity (1.000).

For all wells that we studied, the TDS (in mg/L) measured is equal at 0.56 times the conductivity (in µs/cm) measured. The card of distribution of the TDS in the studied wells is superimposable to the card of distribution of the conductivity in these wells.

The TDS of the studied well water varies from 37mg/L to 632 mg/L.

Turbidity

The turbidity of water is caused by the presence of substances that are suspended in water, for example: the clay, the silts, the colloidal organic particles, the plankton and of other microscopic organisms (DEGBEY, 2004). When the turbidity is lower in 5 FNU, Water is clean. When it is understood between 5 and 30 FNU, water is slightly troubled and when the turbidity is superior in 50 FNU, water is troubled (GOMEZ, 2009). When the turbidity is raised, water is colored.

According to the norms of Benin of February 20th 2011, the turbidity of a water destined to the consumption must be lower or equal to 5FNU.

65% of the studied wells have a turbidity compliant to the Beninese norms for a drinking water.

The turbidity of the waters of well analyzed varies from 1 to 18 FNU.

All wells moved away relatively from the Nokoué lake (well n°9 to 20) have more lucid waters (turbidity 4 FNU) that the rainwaters meteoroid (turbidity = 9 FNU): Soil filters the waters of infiltration.

The waters of the wells near of the lake (well n°1 to 8) are slightly troubled (4 FNU <turbidity 18 FNU). These last wells are polluted by the Nokoué lake that is troubled (equal turbidity in 55.5 FNU about) and colorful. These wells are slightly troubled because the water of the lake

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charged of matters in abeyance nourishes these wells; but at the time of the passage of the water of the lake toward the wells, water is filtered by the rocks and ridded of a part of the substances and matters.

The wells 3 and 4 have an elevated turbidity (18 and 14 FNU) because, downstream these wells, the lake is disturbed very by the human activities. These places are the ambarcadaires where one unloads some dugouts, the fished fishes and of the contraband gas and a part of these products is poured in the lake.

The turbidity of the wells n°7 and 8 are raised (17 and 14 FNU) because of the same commercial exchanges downstream these wells in the lake.

Potential Redox

According to the matrix of interrelationship (picture 16) the potential redox is bound greatly and vice versa to the pH (- 0.892) and to the turbidity (- 0.758).

The potential redox of the studied well waters varies from 183 mV to 326 mV.

The potential redox of the wells moved away of the lake (well n°9 to 20) is superior to the potential redox of the wells near of the lake (well n°1 to 8) that is superior to the potential redox of the water of the lake.

On the other hand the turbidity and the pH of the waters of the wells moved away of the lake are lower to those of the wells near of the lake.

So, contrary to the turbidity and to the pH, the potential redox of the waters of the wells moved away of the lake is raised more than the one of the wells near of the lake it is because the potential redox is bound greatly and vice versa to the turbidity and to the pH.

Lead

Lead is a poisonous substance. The presence of lead in the underground water can come from a contamination by a water of surface or can come from soil. Lead is naturally present in soil in height of a few score of soil mg/kg (BOSSOU, 2002).

According to the instructions of the European Union of the 03/11/98 for a drinking water, the content made of lead of a consumption water must not exceed 50µg/L.

All studied well waters have contents made of lead conform to the norms of the union European. The content made of lead of these waters varies from 0 in 30 µg/L. the waters of the wells relatively moved away of the lake (well n°9 to 20) but the well n°13 have a content made of lead understood between 2 and 4 µg/L. This weak pollution comes from soil. In general, the waters of the wells near of the lake have a weaker content made of lead. This very weak pollution has for origin the lake that with its waters poor in lead diluted the waters of these wells with regard to lead.

Zinc

Zinc is an undesirable substance in water. The presence of zinc in the underground water can come from a contamination by the waters of surface or can come from soil. Zinc is naturally present in soil. It is more abundant than lead in the terrestrial crust.

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According to instructions of the European Union of the 03/11/98 for a drinking water, the content made of zinc of a water destined to the consumption must exceed 5mg/L.

All studied well waters have contents made of zinc conform to the norms of the European Union. The content made of zinc of these waters varies from 0 to 0.8mg/L. The waters of the wells relatively moved away of the lake (well n°9 to 20) but the well n°17 have a weak content made of zinc (lower to 0.2 mg/L). This weak pollution comes from soil. The waters of the wells near of the lake have a content made of more elevated zinc (enters 0.2 and 0.8 mg/L) with an average of 0.46 mg/L that is as equal to the average of the contents made of zinc in the waters of the lake. This, not only confirms that the waters of the lake nourish the wells near of the lake but watch that at the time of the passage of the water of the lake toward the wells, ions zinc is not filtered by soil.

The cards of distribution of the physical and chemical parameters that we have just presented put in inscription the pollution of the waters of attributable well to soil and the extent of the pollution of the wells (well n°1 to 8) by the Nokoué lake.

Some physical parameters that we measured have neighboring values for all wells. It is about the temperature, of the dissolved oxygen and of the percentage of oxygen saturation. The presence of the lake didn't influence these parameters to the level of the wells near of it. The temperature varies from 26.2 to 26.9°C in the studied wells. The oxygen dissolves and the percentage of oxygen saturation varies respectively from 1.83 to 2.87 mg/L and 22.3 to 35.1%.

According to the Moroccan Norm NM 03.7.001 of the oxygen dissolved in a water of consumption must be consistent between 5 and 8mg/L. All waters of well analyzed have some contents below the lower doorstep of the Moroccan Norm. But, most present bacteria in the fecal matters are anaerobic optional, so that, the dissolved oxygen, in weak concentration in the studied well waters, influence very little their survival in soil.

It is agreed to underline that a water of temperature situated between 25 and 28°C constitutes a middle of culture for microorganisms of the environment (Makoutodé and al, 1999; GOMEZ, 2009). The temperatures of waters sampled create a milieu favorable to the microbial development activity.

RESULTS AND MICROBIOLOGICAL PARAMETER INTERPRETATIONS

A certain number of bacterial species normally absent from a person's intestine in good health, can be secreted in an intermittent way and in variable quantity according to the place and the state of health of the population. These pathogenic, or potentially pathogenic bacteria, are responsible for most infectious illnesses that rage in subtropical Africa: cholera, typhoid fever, dysentery, gastroenteritis, diarrhea,…Generally transmitted to mankind by digestive way bound to the consumption of water or food contaminated, the pathogenic bacteria play a determining role in biological pollution of table water from a latrine (BOSSOU, 2002). The pathogenic bacteria are not always omnipresent in the fecal matters contrary to the indicatory bacteria of the fecal pollution. It would be an illusion to base the tests of fecal contamination solely on the systematic research of pathogenic bacterial species. The best approach consists in a research of the indicatory bacteria of the fecal pollution, completed by a possible research of specific pathogenic germs.

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Banal Germs

The first microbiological parameters that we measured, for every sample, are the banal germs. A water cannot contain any germs, it is said very healthy or very pure then. In the case where a water of well contains some, it must contain to the maximum of 50 germs/mL (norms of Benin). Water is qualified of healthy and one can consume it. Beyond this value, water is suspected and it is necessary to search for in water the indicatory bacteria of the fecal pollution.

The concentration in banal germs of the waters of well analyzed varies 75 to 3.9 10^3 by ml of water. All these waters are not compliant to the norms of Benin for a drinking water.

The waters of well near of the lake (well n°1 to 8) contain several times more of banal germs in relation to the well moved away of the lake (well n°9 to 20).

As the cards of distribution of the physical and chemical parameters that we presented, the card of distribution of the banal germs permits to identify the wells whose pollution is influenced by the waters of the lake.

All waters of well analyzed are suspected (more than 50 banal germs by ml of water). It is why we searched for the indicatory bacteria of fecal pollution (total coliforms, coliforms thermotolerants, *Escherichia coli* and intestinal enterococci).

Total Coliforms

The group of the coliforms consists of the bacteria belonging to the family of the Enterobacteriaceaces and makes to two entities appear: one is mainly the one of the coliforms of fecal origin or coliforms thermotolerants hosts of the digestive tube of the man and animals warm-blooded; the other of non-fecal origin, is part of the aquatic bacterial communities (comes of the infiltration waters) or telluric (comes of the earth).

A drinking water must not contain any total coliforms (0/100 ml) according to the norms of the WHO.

All waters of the wells studied are not compliant to the norms of the WHO for a drinking water.

The concentration of these waters in total coliforms varies from 400 to 3.3 10^5 in 100mL water.

The waters of most wells near of the Nokoué lake (well n°2 to 8) are polluted excessively by the total coliforms (enters 9.8 10^4 and 3.3 10^5 in 100mL). All waters of the wells relatively moved away of the lake are less contaminated. They contain less than 6 10^4 total coliforms in 100mL water.

The reasons of contamination of these waters of well are numerous:

- Insufficiency of purification works, inefficiency of the protective devices of the wells and lack of hygiene around the wells.
- The non-tightness of the wells and latrines.
- Not only the table water of weak depth (especially very close to lake) communicates with the content of the latrines that loads the waters of well of coliforms thermololerants but also, this weak depth of the tablecloth makes easy and fast the acquirement of other total coliforms by the waters of well from the waters of infiltration.

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The near well waters contain a lot more total coliforms than those of the distant wells in general because the risks of contamination that we have just enumerated are distinctly more elevated to the level of the wells near of the lake. Broadly speaking the concentration in total coliforms varies appreciably from a well to the other because these risks of contamination vary from a well to the other.

We recall that the pathogenic bacteria where potentially pathogenic responsible most infectious illnesses that rage in subtropical Africa are of fecal origin. The research of coliforms thermotolerants (one coins group of the total coliforms) mainly of fecal origin will indicate if these waters are inheritable to contain pathogenic germs.

Coliforms Thermotolerants

The species the more frequently associated to this bacterial group is the Coli Escherichia and in a least measure, some species of the Citrobacter kind, Enterrobacters and Klebsiellas (Elmund and al, 1999; Canada health, 1991; Edbery and al, 2000; GOMEZ, 2009). The bacterium *Escherichia Coli* represents all time 80 to 90% of the coliforms thermotolerants detected (Edberg and al, 2000; GOMEZ, 2009).

The interest of the detection of the coliforms thermotolerants, as indicatory organisms of fecal pollution, resides in the fact that their survival in the environment is generally equivalent to the one of the pathogenic bacteria and that their density is generally proportional to the degree of pollution produced by the fecal matters (CEAEQ, 2000; GOMEZ, 2009).

According to the norms of the WHO, a water destined to the consumption must contain coliforms thermotolerants (0/100mL).

All the waters from the wells analyzed contain some coliforms thermotolerants and are not compliant to the norms of the WHO.

The concentration in coliforms thermotolerants of these waters of well varies from 20 to 9 10^4 in 100mL water.

All waters of the wells near of the lake (well n°1 to 8) have some concentrations in coliforms thermotolerants understood between 7 10^3 and 9 10^4/100mL water. The waters of the wells moved away of the lake (well n°9 to 20) are all less polluted by the coliforms thermotolerants because the risks of contaminations enumerated previously are less elevated for these wells.

Although the presence of coliforms fecal thermotolerants usually reveals a fecal origin contamination, several fecal coliforms is not of fecal origin. They can come from waters enriched in organic matter, like the industrial sewages of the sector of the doughs and papers or of the food transformation (WHO, 2000; GOMEZ, 2007). It is why it is appropriated more to use the term generic “coliforms thermotolerants” rather than the one of “fecal coliforms” (WHO, 1994; Robertson, 1995; GOMEZ, 2009).

Only the *Escherichia coli*, a species belonging to the coliforms thermotolerants is a specific indicator of a fecal contamination and his/her/its presence indicates the presence possible of microorganisms pathogenic enteric.

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Escherichia Coli

The *Escherichia coli* is a bacterial species belonging to the group of the coliforms thermotolerants themselves belonging to the group of total coliforms. The *Escherichia Coli* are very abundant in the human and animal intestinal flora and it is the only species that either strictly of fecal origin. Their presence in water means that this last is contaminated by a fecal origin pollution and that it can contain pathogenic microorganisms therefore (French Ministry lasting Development of the environment and Parks, 2012).

According to the norms of the WHO, a water destined to the human consumption must contain some *Escherichia Coli* (0/100mL).

40% of the studied wells don't contain a *Escherichia coli*. The concentration of *Escherichia coli* in the rest of the wells varies from 20 to 6.4 10^4 in 100mL water.

In 100mL water of each of the studied wells, there is less *Escherichia coli* than of coliforms thermotolerants and less coliforms thermotolerants that of total coliforms. It proves a consistency in the results that we got because the *Escherichia coli* is a species belonging to the subgroup of the coliforms thermotolerants and these last belonging to the group of the total coliforms.

All waters of the wells situated the Nokoué lake very close to (well n°1 to 8) are contaminated by the *Escherichia Coli* with concentrations generally very elevated and only the third of the waters of the wells moved away of the lake (well n°9, 10, 12 and 19) are contaminated by the *Escherichia coli* with less elevated concentrations.

These containing waters of the *Escherichia Coli* are contaminated therefore by the fecal matter capable to contain pathogenic germs. To identify to the level of each of the wells concerned if the fecal pollution is of human or animal type, in addition to the concentrations of the coliforms thermotolerants we need the concentrations of the intestinal enterococci in these waters.

Intestinal Enterococcis

The group of intestinal enterococci consists of fecal and non-fecal origin species (plant, bugs, soil) that one cannot discern with the help of the simple tests. Also, the intestinal enterococci's they are not of good indicators of the fecal pollution. However, considering their strong resistance and their inability to increase in the aquatic environment, the intestinal enterococcus can be used like indicators of the pathogenic bacteria (that increase little in the aquatic environment) and of the viruses (that survive longer in aquatic environment that the coliforms thermotolerants) (LECLERC and MOSSEL, 1989; BOSSOU, 2002).

According to the norms of the WHO, a drinking water must not contain any intestinal enterococci.

All waters of well analyzed contain intestinal enterococci and are not therefore compliant to the norms of the WHO.

The concentration in intestinal enterococci of these waters varies from 40 to 10^4 in 100mL water.

The middle concentration in these enterococci of the waters of the wells near of the lake is raised more than the one of the wells moved away of this lake.

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The report coliforms thermotolerants / intestinal enterococci is generally superior to 4 in the human and lower fecal matters to 1 in the animal fecal matters. This property is used in the research of the intestinal enterococci to determine if the pollution (fecal) is of human or animal origin (BABA-MOUSSA, 1994; BOSSOU, 2002).

50% of the studied well waters are contaminated by the fecal matter of human origin. It is about all wells situated the lake very close to and of the wells n°9 and 10.

5% of the studied wells are contaminated by the fecal matter of animal origin (this well is situated to some meters of the site of raising of pigs of the Faculty of the Agronomic Sciences from the university of Abomey-Calavi to Benin) and 5% of the studied wells are contaminated by the fecal matter of mixed origin (animal and human).

This work revealed that all studied well waters are much polluted and identify the human as the main person responsible of the bacteriological contamination of these waters. This work also permitted to note that the cards of distribution of the parameters measured in the wells reveal the extent of the part of the table water of which the level of pollution is influenced by the Nokoué lake. The contrast is big between the values measured in the waters of well near of the lake and those measured in the waters of the wells moved away of the lake for the following parameters: pH, turbidity, potential redox, banal germs and coliforms thermotolerants.

Measured Parameters	**well near of the lake: well n°1 to 8**	**well distant of the lake: well n°9 to 20**
PH	6.5 à 7.2	4.3 à 6.4
Turbididy	5 à 18 FNU	1 to 4 FNU
Potential redox	183 à 209 mV	209 to 326 mV
Banal germs	1.7 10^3 à 3.910^3 / Ml	75 to 840/ mL
coliforms thermotolerants	7 10^3 à 9 10^4 /100Ml	20 à 6.1 10^3 /100mL

If the proximity of the lake was beneficial with regard to the pH of the wells near of the lake that is compliant to the norms of the European Union, with regard to most measured parameters, the proximity of the lake is an aggravating factor of the pollution of the waters of well.

The predominance of the human fecal contamination of these waters puts the accent on the fact that mankind is the main actor of the destruction of his environment and in particular the increasing deterioration of the water quality. Men and women fall sick, while drinking water contaminated by their own fecal matters. The roof is for years the apparition of a cholera epidemic in the zone of survey and that worsens with the passing of the time. These results confirm those gotten by EL HAISSOUFI and al in 2011 and must be the object of a media beating in order to allow the population concerned to take the measure of the danger, to take knowledge and especially to apply the palliative measures of which here are some:

The respect of the at least 15 m distance recommended by the WHO that must separate the latrines of a well.

Extend the network of purification to the whole zone of survey.

Building of the protective devices of the wells.

Respect the rules of hygiene around the wells, at the time of the withdrawal, the transportation and the storage of the consumption water.

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Insulated latrines-Built to replace the existing latrines currently in the zone of survey.

Insulated-Render the lateral partitions intern some wells.

The role of the government in the struggle against the proliferation of the illnesses related to water in the zone of survey is fundamental and must pass by:

The Extension of the network of drinking water adduction.

An adequate organization of the abduction of garbage.

A depollution of the water plans of which the Nokoué lake. The transportation on this lake (contraband gas) and the fishing must be controlled and consistent.

CONCLUSION

This work permitted to note that all waters of well of the survey zone are polluted on the plane physical and chemical and microbiological.

In the physical and chemical area, the pH, the electric conductivity and the turbidity are respectively compliant to the advisable norms in 40%, 60% and 65% of the waters of the wells analyzed. The contents made of lead and in zinc of these waters are compliant to the norms of the WHO.

On the microbiological plan, all waters of well analyzed are contaminated by the banal germs, the total coliforms, the coliforms thermotolerants and the intestinal enterococci. 60% of these waters are contaminated by the *Escherichia Coli*, a fecal contamination mainly of human origin.

This work also permitted to note that the cards of distribution of the parameters permitted to surround the extent of the space of influence of the Nokoué lake on the pollution of the waters of well.

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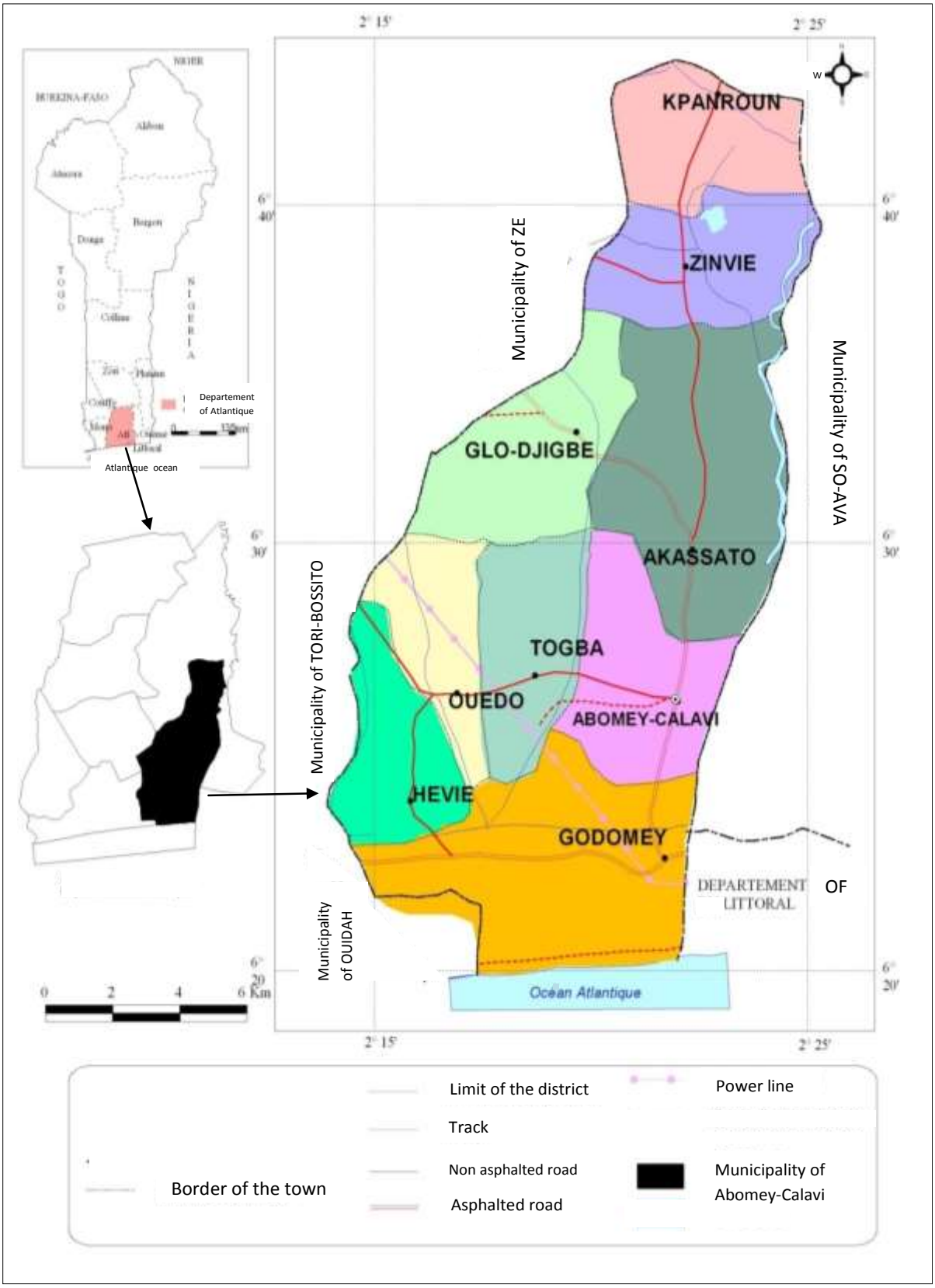
APPENDIX



Pic 1: Location of the municipality of Abomey-Calavi

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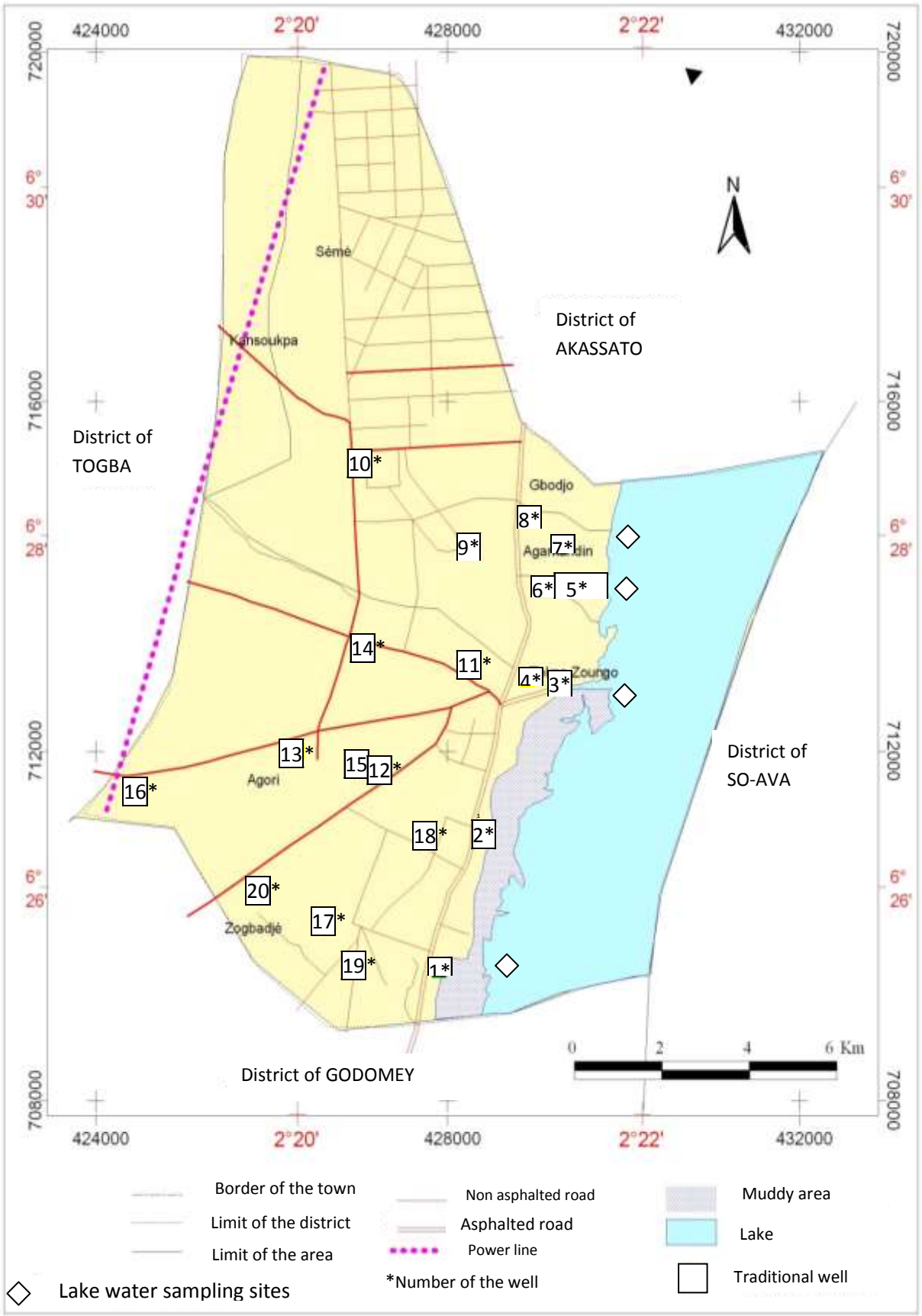

Picture 2 : Water sampling sites

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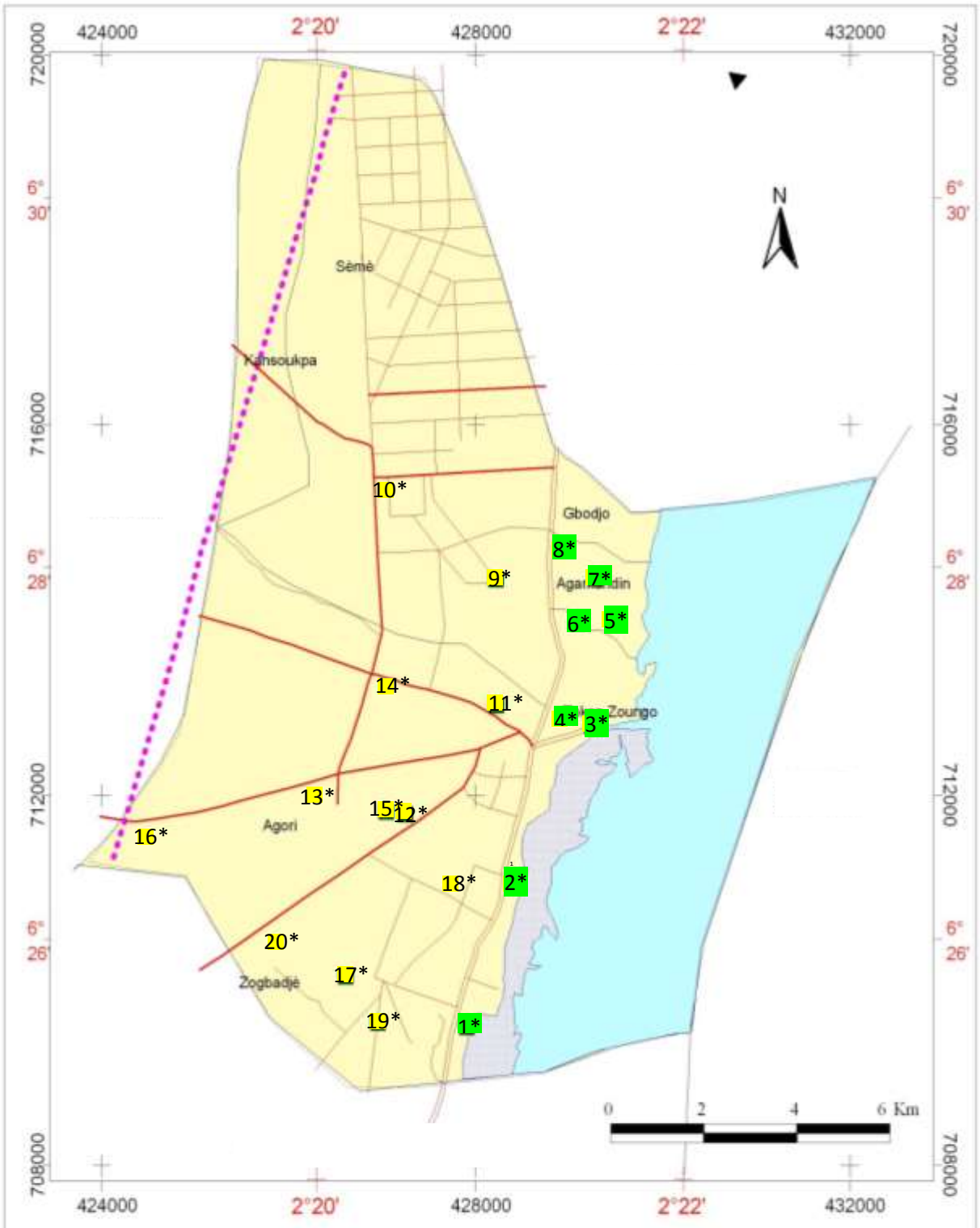
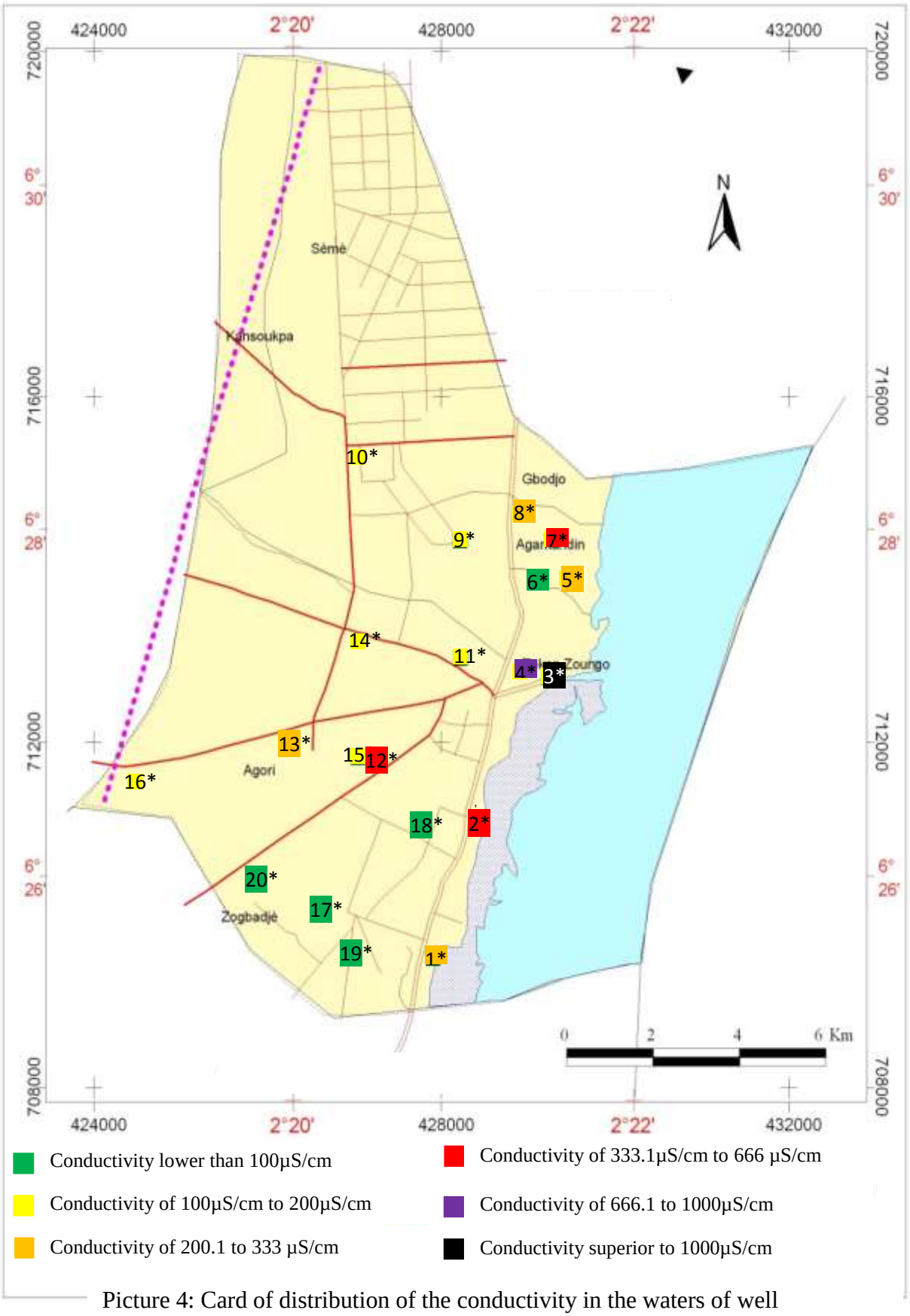


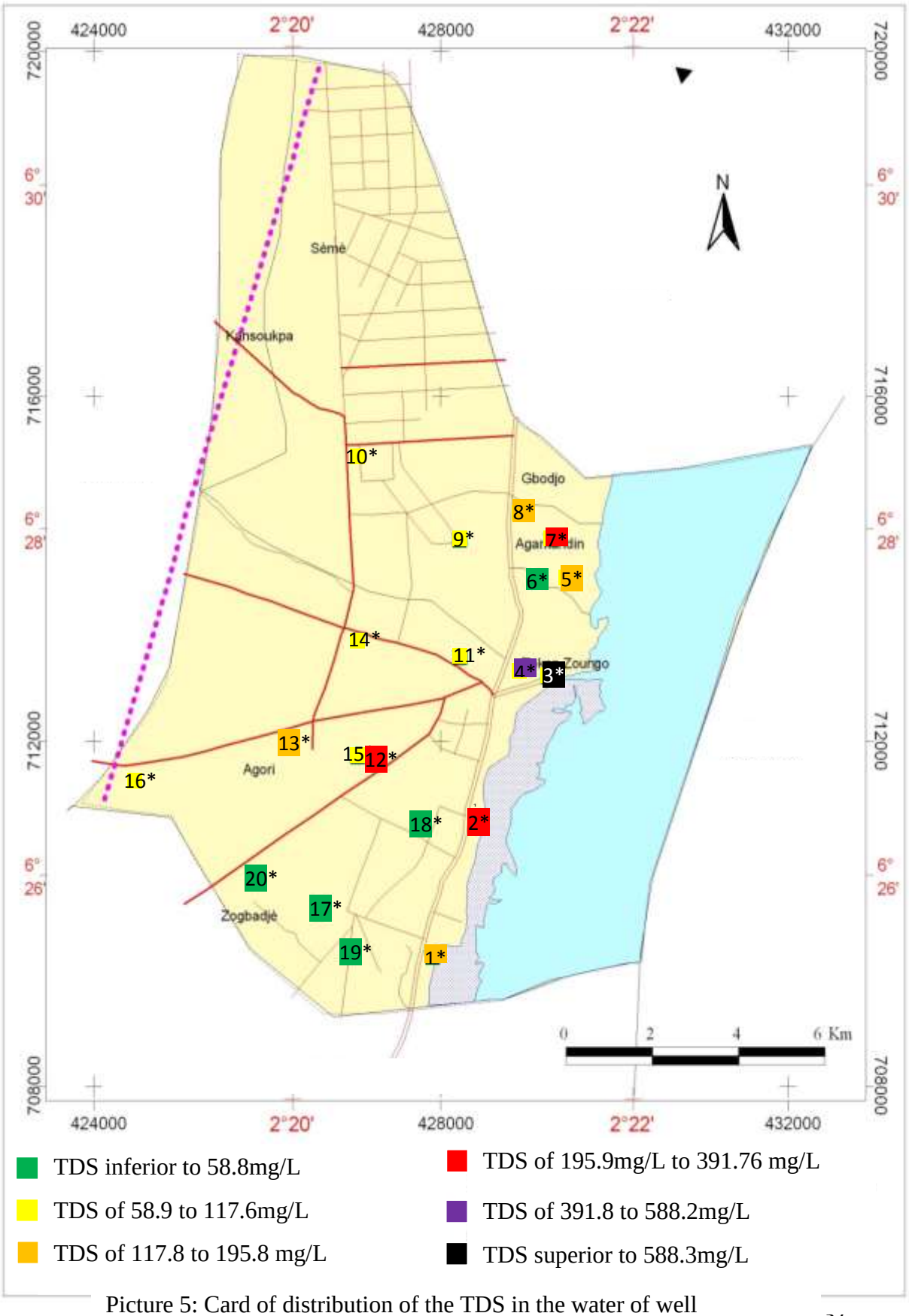
pH understood between 4.3 and 6.4

pH understood between 6.5 and 7.3

Picture 3: Card of distribution of the pH in the waters of traditional well



Picture 4: Card of distribution of the conductivity in the waters of well



Picture 5: Card of distribution of the TDS in the water of well

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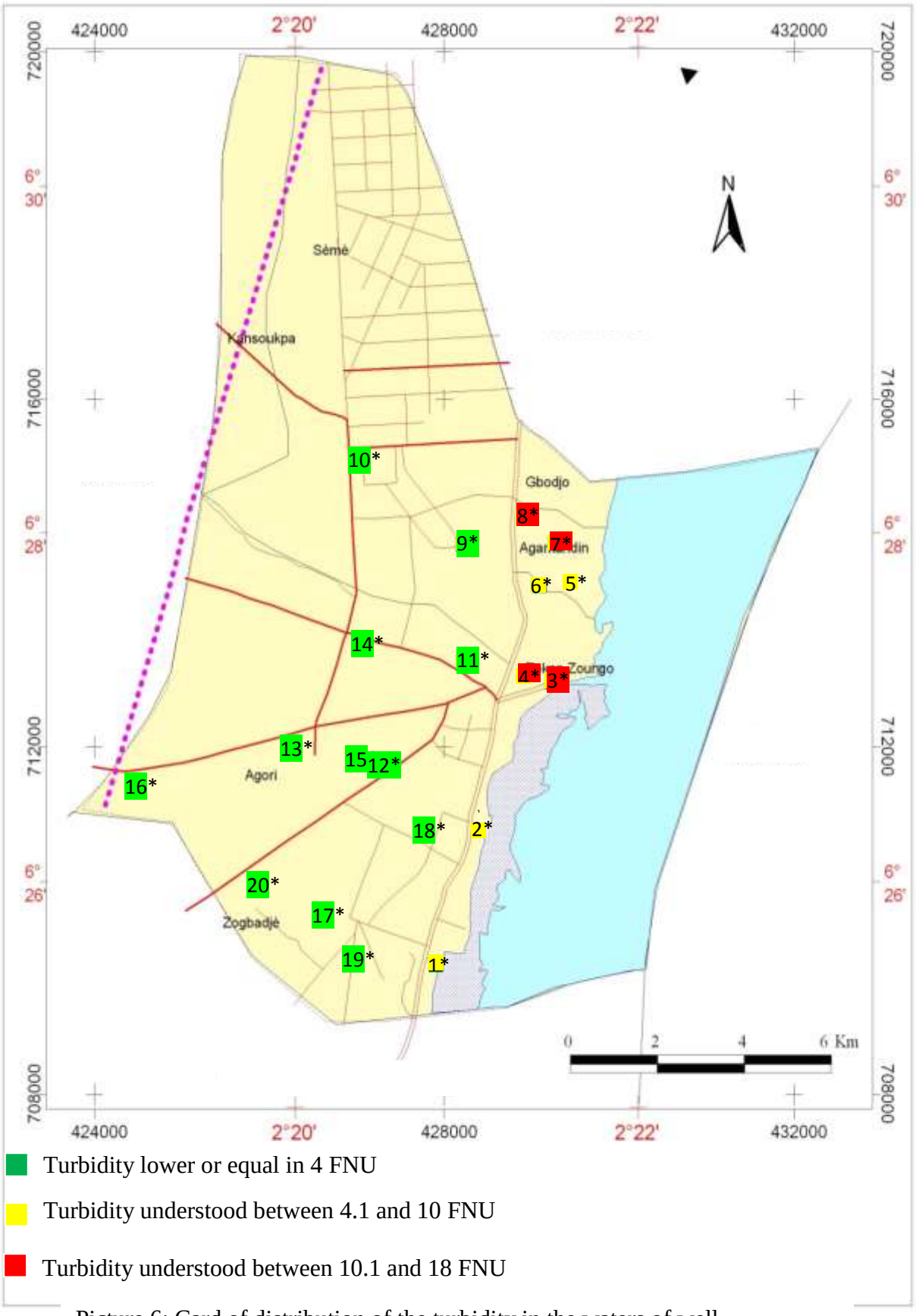
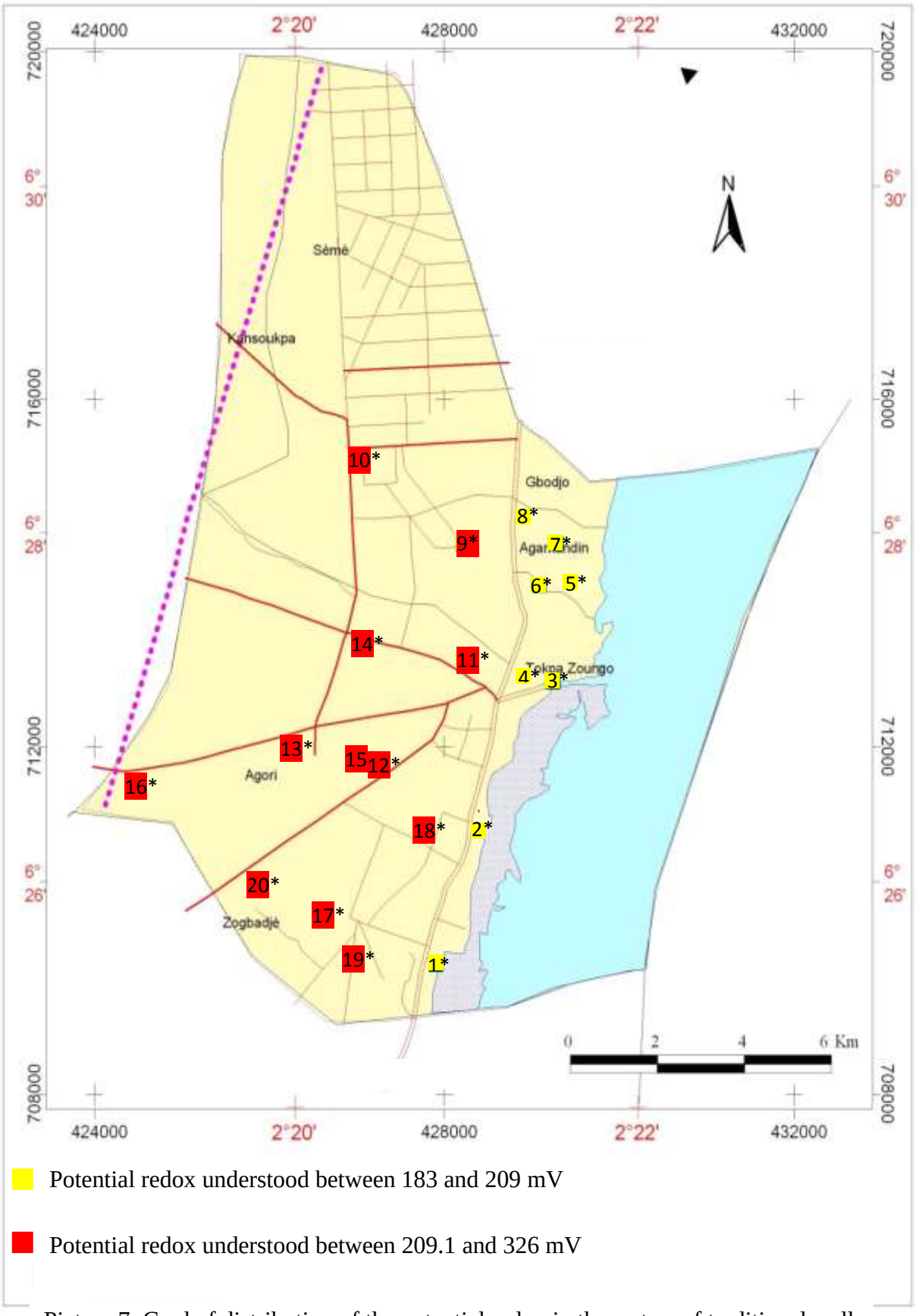


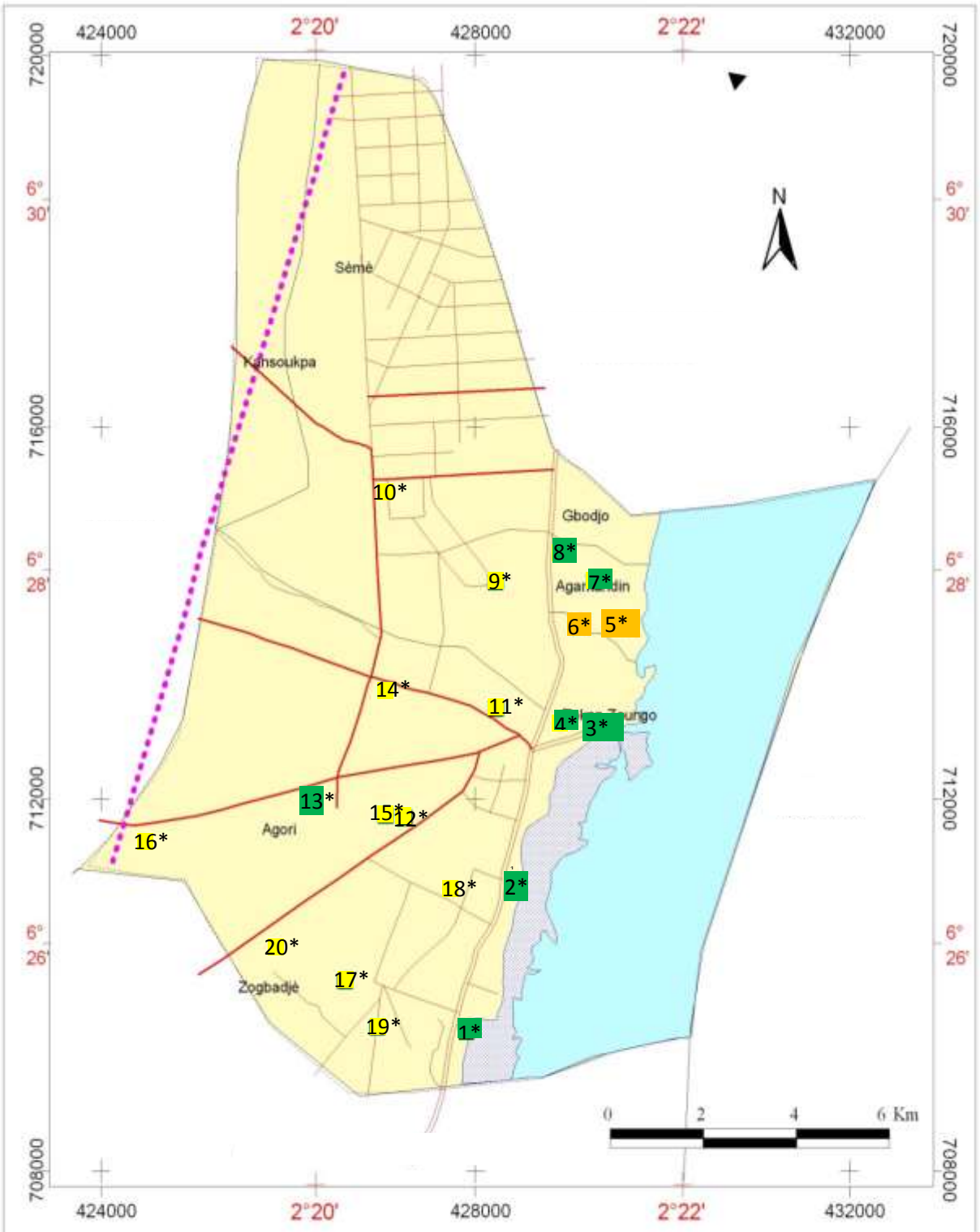
Picture 6: Card of distribution of the turbidity in the waters of well.



Potential redox understood between 183 and 209 mV

Potential redox understood between 209.1 and 326 mV

Picture 7: Card of distribution of the potential redox in the waters of traditional well

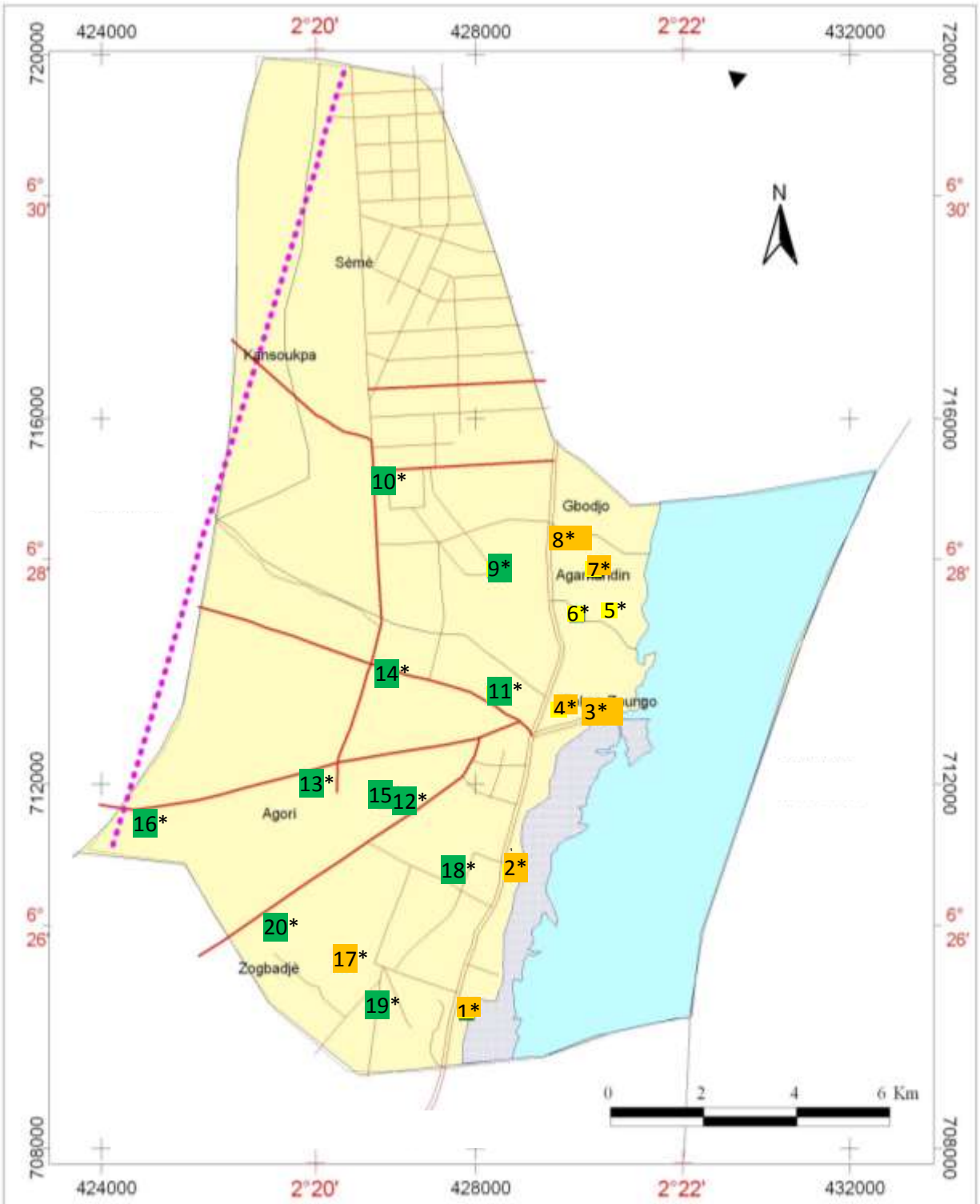


Content made of lead lower to 1µg/L

Content made of lead understood between 2 and 4µg/L

Content made of lead understood between 24 and 30µg/L

Picture 8: Card of distribution of the contents made of lead of the water of traditional well

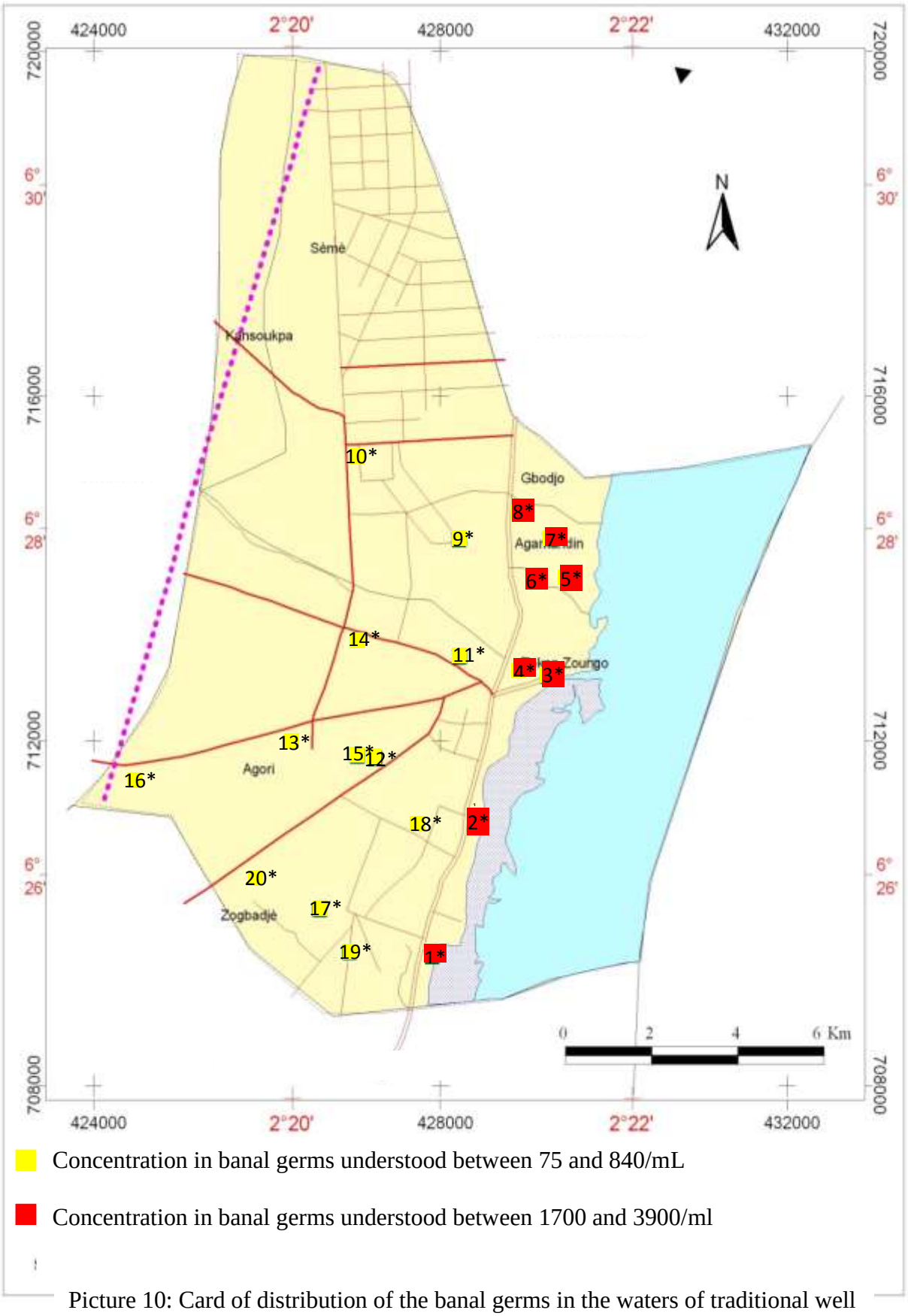


Content in zinc inferior to 0.2mg/L

Content made of zinc understood between 0.2 and 0.35mg/L

Content made of zinc understood between 0.36 and 0.8mg/L

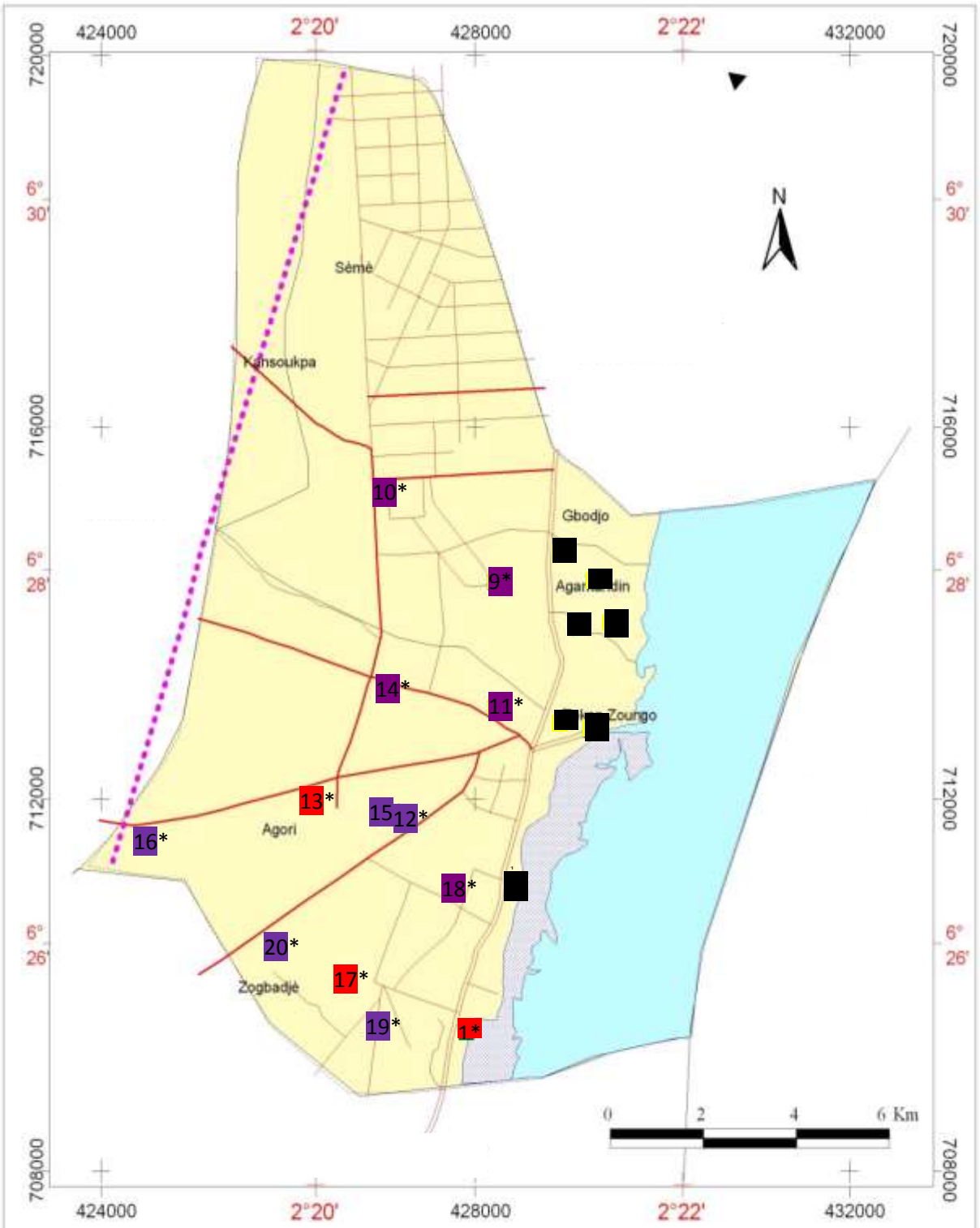
Picture 9: Carte of distribution of the contents made of zinc of the waters of traditionne well



Concentration in banal germs understood between 75 and 840/mL

Concentration in banal germs understood between 1700 and 3900/ml

Picture 10: Card of distribution of the banal germs in the waters of traditional well

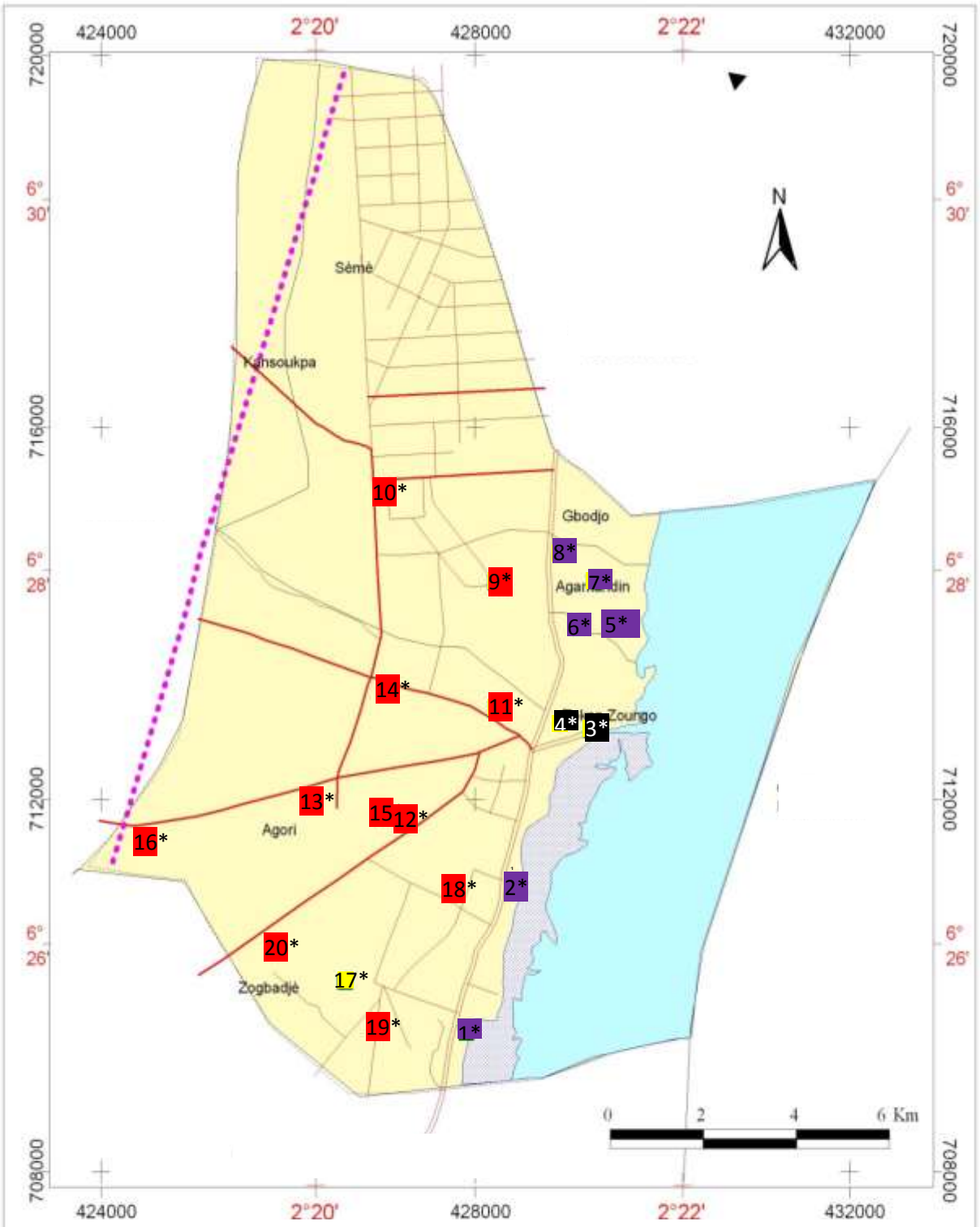


Concentration in total coliformes understood between 400 and 1900/100mL

Concentration in total coliformes understood between 5200 and 60000/100mL

Concentration in total coliformes understood between 98000 and 330000/100mL

Picture 11: Card of distribution of the concentrations of the total coliforms in the water of well



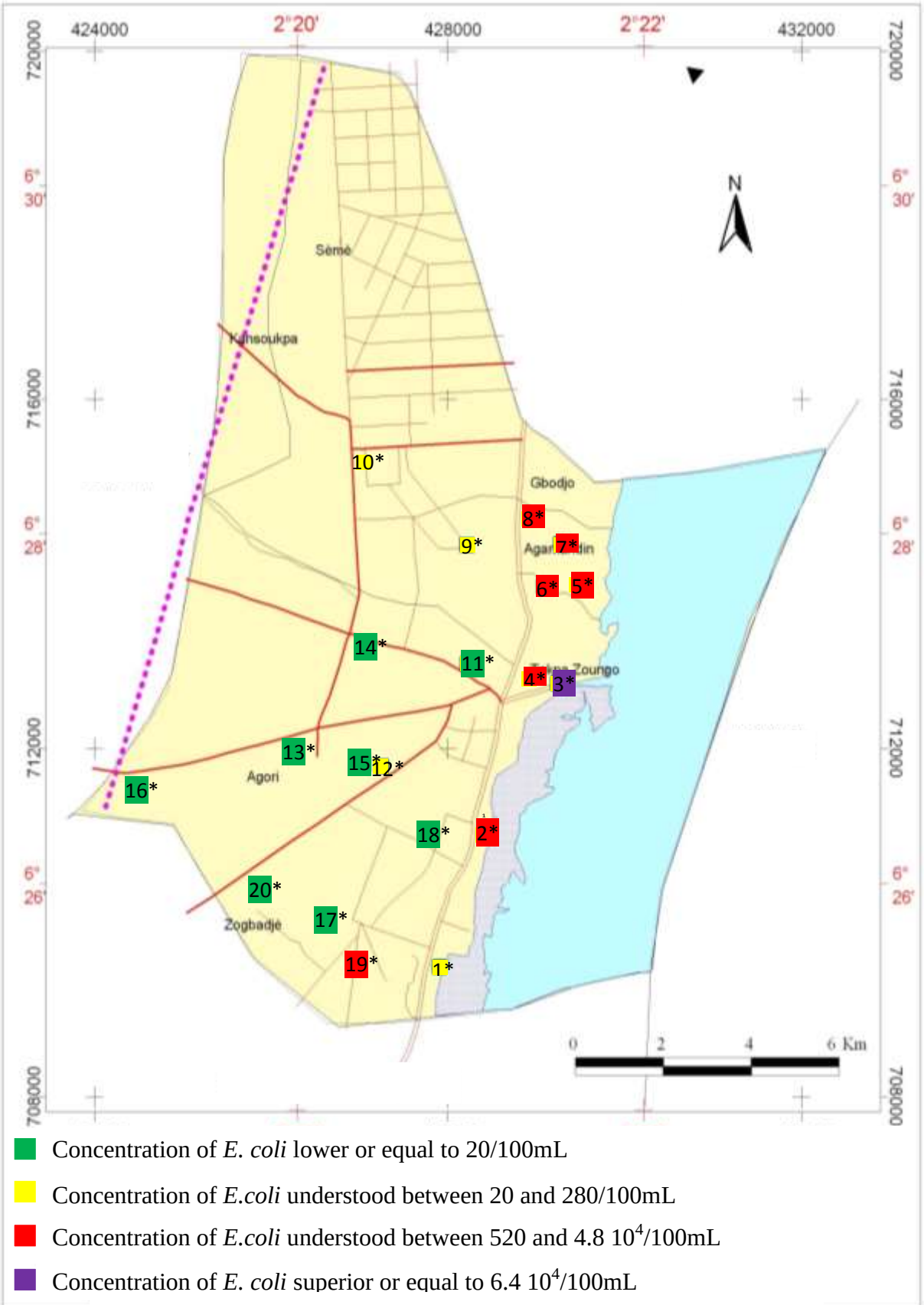
Concentration in coliform thermotolerants lower or equal to 20/100mL

Concentration in coliform thermotolerants understood between 440 and 6.1 10^3/100mL

Concentration in coliform thermotolerants understood between 7 10^3 and 3.3 10^4/100mL

Concentration in coliform thermotolerants understood between 6.9 104 and 9 10^4/100mL

Picture 12: Card of distribution of the coliforms thermotolerants in the waters of well



Concentration of *E. coli* lower or equal to 20/100mL

Concentration of *E.coli* understood between 20 and 280/100mL

Concentration of *E.coli* understood between 520 and 4.8 10^4/100mL

Concentration of *E. coli* superior or equal to 6.4 10^4/100mL

Picture 13: Card of distribution of *Escherichia coli* in the waters of well

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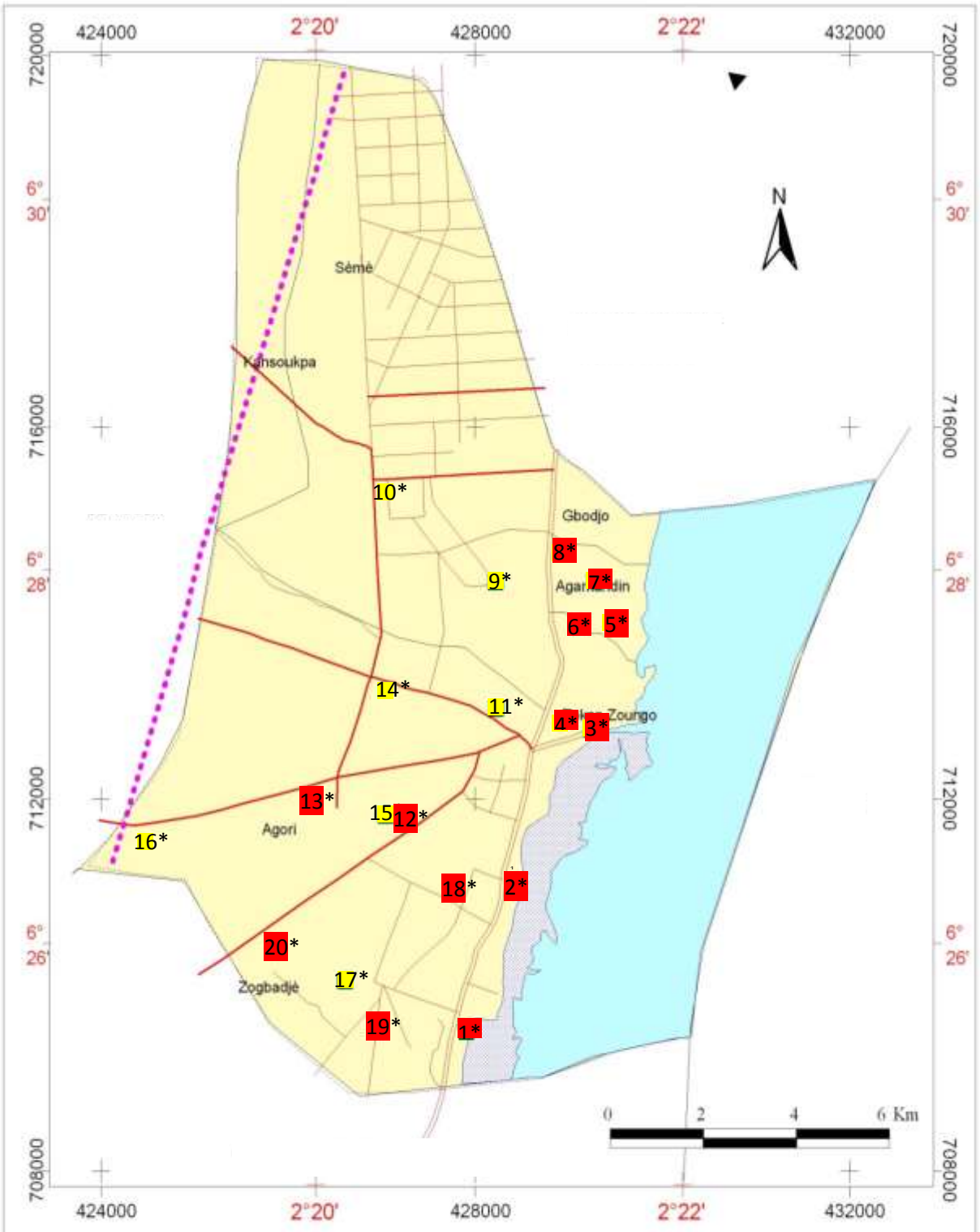
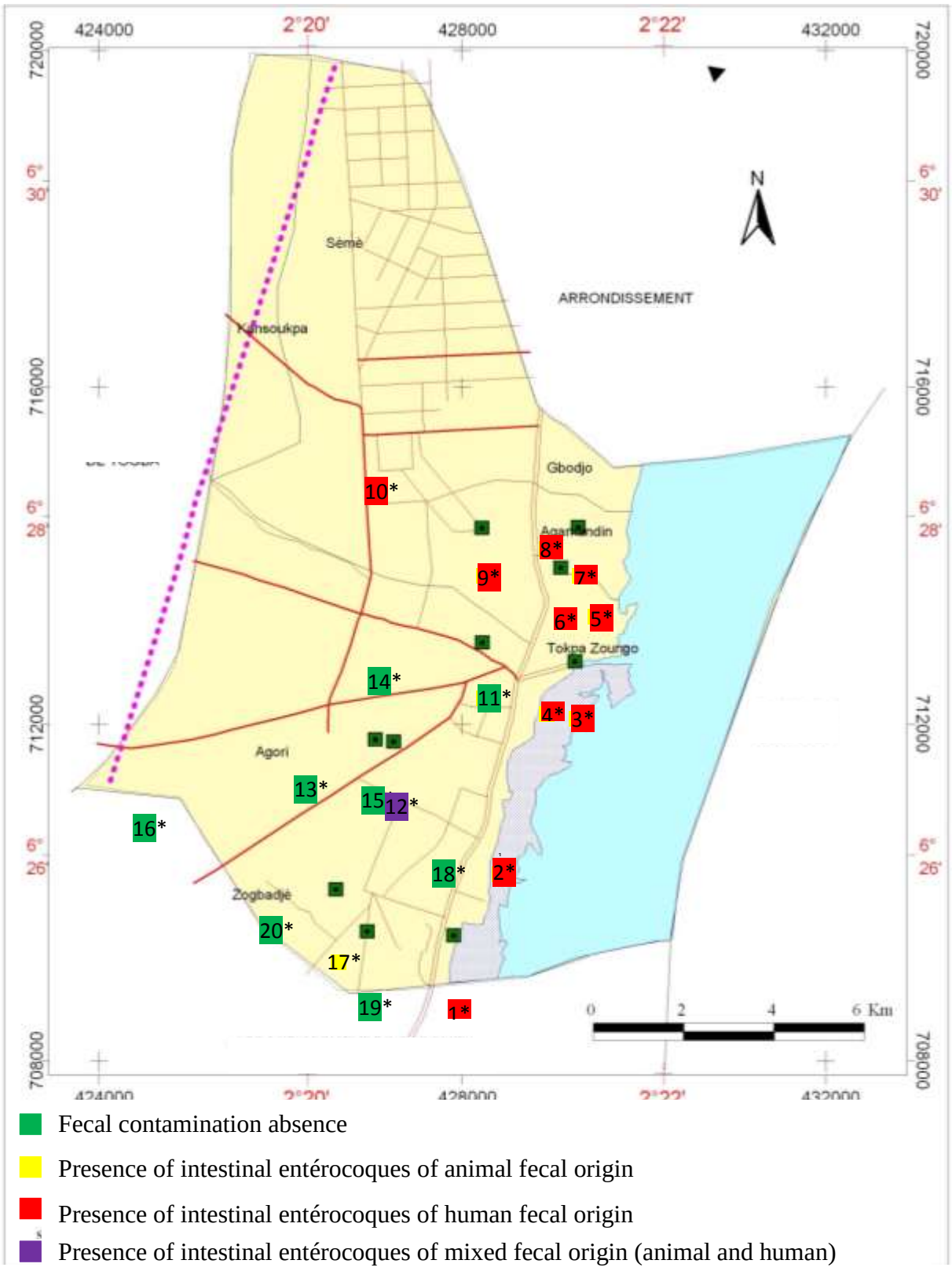


Concentration of the intestinal enterococcis lower or equal to 896/100mL

Concentration of the intestinal enterococcis understood between 1.4 10^3 and 10^4/100mL

Picture 14: Card of distribution of the intestinal enterococcis in the waters of well



Picture 15: Card distribution of the origin of the fecal contamination in the waters of well

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