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Assessment of physicochemical quality of water from Groundwater in the areas of Northwest of Morocco and Health hazard

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Abstract
Groundwater is a major source of water for drinking, agricultural, and industrial desires. The availability of water determines the location and humans activities in an area and our growing population is placing great demands upon natural fresh water resources. These resources are sometimes exposed to various forms of pollution such as agricultural, industrial and residential wastes. This work's aim is the assessment of the physicochemical quality of well's water in the region of Northwest of Morocco, which is used in the supply of drinking water for a large population. The results obtained in this study show that the analysed water has a conductivity that varies between 527µs/cm and 10790 µs/cm. Nitrate concentrations varies between 0,15mg/l and 173mg/l with 21,43% wells that exceed the maximum allowable value (MAV). Sulfates concentrations are not exceeding the maximum permissible value except one well (622,56mg/l) that is exceeding the MAV. A chloride concentration varies between 82,00mg/l and 3631mg/l, two wells have levels exceeding the MAV. Concentrations of major ions (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+},…) as well as the values of the parameters (pH, temperature, hardness,…) do not exceed the ones recommended by the Moroccan standard(NM 03.7.001, 2006) relating to drinking water.

Keywords: Groundwater, physicochemical, quality, Northwest of Morocco.

Introduction
For several years, the increasing of water resource deficit has contributed to the degradation of its quality, As indicated by the World Health Organization [1], the degradation of the water quality becomes a serious problem for public health, Shortage of drinking water worldwide is becoming very acute nowadays [2].In Morocco, the groundwater is an important part of the hydraulic heritage of the country. Groundwater represents an important source of drinking water and its quality is currently threatened by a combination of over-abstraction and microbiological and chemical contamination [3].
Water intended for human consumption must not contain pathogen germs or harmful chemicals; because water contaminated with microorganisms is the cause of epidemics [4]. In addition, nitrate pollution of drinking water can cause methemoglobinemia or "blue baby" to infants and carcinogenic diseases to adults [5]. Meteorological events and pollution are a few of the external factors which affect physicochemical parameters such as pH, TDS and conductivity of the water. They have a major influence on biochemical reactions that occur within the water. Internal factors, on the other hand, include events which occur between and within bacterial and plankton populations in the body of water [6].
The main objective here is to determine the water quality stemming from this region by analyzing certain pesticides and metal elements, by using chromatography and atomic absorption techniques respectively, establishing the cause of contamination and the associated health risks that may be hazardous to the population.

2. Materials and Methods

2.1. Presentation of the studied area

The studied area, the northwest of Morocco (Fig1), has major rivers as a hydrous system (Sebou, Rdom,…) the geology is characterized by surface outcrops of limestone and Sandstone Mountains of Jurassic limestone hills surrounded by Miocene marls, which constitute the major part of the landscape[7]. The agriculture is the main activity in this zone, favored by good weather conditions and fertile soils. This region represents 0, 4% of the country witch a 281.000 hectares area (1, 2% of useful national agricultural area) [8].

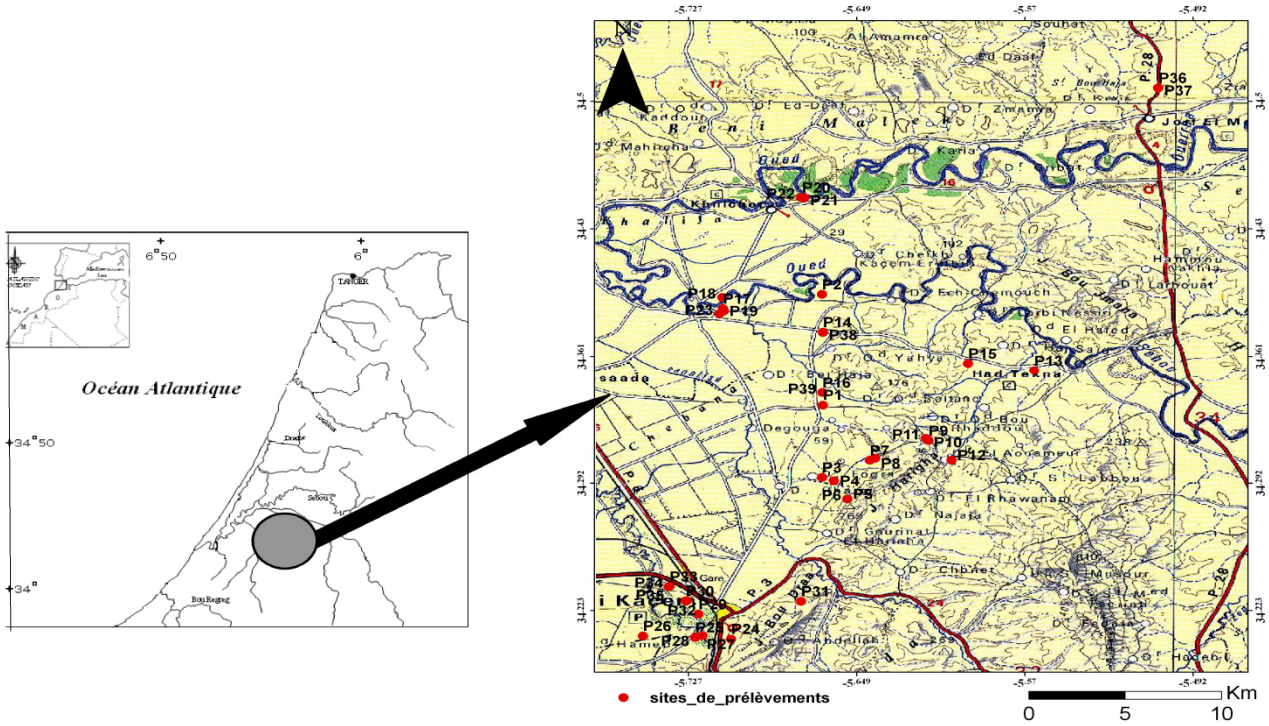

Figure 1: Location of sampled wells (in red).

Groundwater samples from 39 wells were collected from the Northwest of Morocco, covering a total area of 1100km²(Fig.1) for physicochemical examinations. The samples were collected in plastic bottles (PET) of two liters capacity without any air bubbles. Samples were placed at low temperature (4°C) using portable coolers and transported to the hydrology laboratory at the National Institute of Hygiene (NIH) in Rabat. The average of the depth of recorded wells ranges from 6 to 100 meters. For each well, information on the location, the frequency of use, the mode and the nature of the treatment are taken into account.

The analyses of various physicochemical parameters were carried out as per the method described by Jean Rodier (2009) [9]. The temperature, potential of hydrogen (pH) and electrical conductivity were measured at the time of sample collection. The pH was measured with portable field pH Meter, type (WTW pH 330i/SET), conductivity with Handheld Conductivity Meter; type (WTW cond 330i/SET).The temperature was measured by a thermometer built into the conductivity Meter and the pH Meter. Nitrate (NO_3^-), nitrite(NO_2^-), ammonia nitrogen (NH_4^+) and sulfate (SO_4^{2-}) are determined by a colorimetric method using a UV/visible spectrometer type (JASCO V-530).Total hardness (TH), calcium(Ca^{2+}) and magnesium (Mg^{2+}) were determined the volumetric method wich EDTA (Ethylenediaminetetraacetic-acid).the oxidability (organic materials:OM)is determined by high temperature oxidation in acidic medium. Alkalinity total (AT) and bicarbonate (HCO_3^-) are analyzed by volumetric dosing with 0, 1N HCl. Sodium (Na^+) and (K^+) are determined by excitation of the atoms by flame photometer (type AFP-100).

3. Results and Discussion

The values of physicochemical parameters of water analyses for the 39 wells studied are shown in table 1. Based on the results, temperature, pH, conductivity, nitrites, ammonium, sulfates, chlorides, magnesium and organic matter (OM) recorded values below the standards recommended by the Ministry of health of

Morocco[10] respectively (25°C; 6,5 and 8,5; 2700µs/cm; 50mg/l; 0,5mg/l; 400mg/l; 750mg/l; and 5mg/l). The mean levels of sodium and potassium are respectively about 175mg/l and 2mg/l. Bicarbonates (HCO_3^-) register values between 178,00mg/l and 774, 70 mg/l, respectively observed at the source P8 and P23. For ammoniacal nitrogen, we recorded the absence of both pollutants in groundwater of studied area. OM values were in range of 0,25mg/l (P6) and 2,5mg/l (P1).other parameters, are follows:

Table 1: The variation of physicochemical parameters of wells water in the Northwest area of Morocco.

Wells	Température en °C	pH	C.E en µs/cm	TA en °F	TAC en °F	TH°F	HCO3 en mg/l	Ca en mg/l	Mg en mg/l	Na en mg/l	K en mg/l	Cl en mg/l	SO4 en mg/l	AA en mg/l	Nitrites en mg/l	NO3 en mg/l	OM en mg/l
P1	24,90	7,40	851,00	N.D	27,00	32,20	335,50	78,34	30,79	36,00	1,00	82,00	13,97	N.D	N.D	12,23	0,45
P2	26,01	7,13	813,00	N.D	26,00	34,40	323,30	56,11	49,62	46,00	2,00	99,40	31,29	N.D	N.D	10,26	0,50
P3	26,00	7,20	716,00	N.D	23,50	29,40	292,80	28,08	54,48	42,00	1,00	102,95	8,95	N.D	0,01	14,62	0,40
P4	26,00	8,16	889,00	N.D	23,50	29,20	292,60	64,93	31,62	75,00	1,00	113,60	43,08	N.D	0,01	10,32	0,50
P5	25,60	7,67	1240,00	N.D	29,50	58,40	366,00	178,56	33,68	76,00	1,00	296,34	33,51	N.D	0,01	27,23	0,41
P6	25,50	7,75	1178,00	N.D	28,50	50,50	353,80	146,52	33,91	53,00	1,00	227,12	9,53	N.D	0,01	10,91	0,25
P7	25,20	7,80	946,00	N.D	23,00	29,70	286,70	87,90	18,89	151,00	4,00	245,00	30,12	N.D	0,04	21,10	1,20
P8	25,10	7,55	527,00	N.D	14,00	17,50	178,00	48,66	13,03	40,54	2,00	86,00	67,51	N.D	N.D	0,15	1,30
P9	24,70	7,61	1180,00	N.D	30,50	40,60	378,20	71,60	55,29	282,00	1,00	468,00	60,45	N.D	0,02	41,20	0,71
P10	24,50	7,34	1567,00	N.D	36,50	42,30	451,40	53,12	70,64	109,00	2,00	180,00	46,00	N.D	0,06	63,02	0,55
P11	24,30	7,51	1456,00	N.D	32,00	42,60	396,50	61,00	71,37	146,00	1,00	250,20	58,78	N.D	1,26	173,00	0,73
P12	26,00	7,62	10790,00	N.D	42,00	38,20	518,50	38,00	69,84	2075,00	7,00	3631,65	373,50	N.D	0,05	0,16	2,50
P13	27,00	7,72	1456,00	N.D	22,00	33,00	274,50	81,04	31,10	163,45	8,00	340,21	20,40	N.D	N.D	27,01	0,30
P14	25,90	7,30	1924,00	N.D	21,00	48,80	262,30	173,94	44,26	115,00	1,00	536,05	24,40	N.D	N.D	79,56	0,90
P15	25,80	7,46	5170,00	N.D	35,00	112,80	433,00	71,34	231,04	295,54	5,00	435,94	62,34	N.D	N.D	25,70	1,50
P16	25,70	7,04	2130,00	N.D	28,00	61,20	347,70	121,04	75,40	130,00	3,00	183,18	85,50	N.D	N.D	21,26	0,70
P17	25,60	7,40	2213,00	N.D	52,00	72,00	640,50	68,56	133,27	174,13	3,00	344,32	167,72	N.D	N.D	38,35	0,60
P18	25,40	7,33	5650,00	N.D	49,50	96,00	610,00	133,00	156,77	838,23	2,00	1102,00	622,56	N.D	N.D	132,12	1,50
P19	25,50	7,62	2780,00	N.D	58,50	84,00	719,80	52,14	172,67	265,00	3,00	412,14	108,97	N.D	N.D	15,30	1,50
P20	25,80	7,52	2817,00	N.D	51,00	46,00	628,30	51,20	80,80	320,23	6,00	476,50	334,60	N.D	N.D	5,31	0,60
P21	25,60	7,60	1650,00	N.D	27,50	44,00	341,61	84,50	55,73	150,34	2,00	270,00	125,23	N.D	N.D	13,15	0,40
P22	25,90	7,58	1619,00	N.D	32,00	43,72	396,50	71,00	63,25	136,00	1,00	234,23	177,31	N.D	N.D	16,11	0,41
P23	25,90	7,30	2735,00	N.D	63,00	73,54	774,70	71,45	135,71	258,00	3,00	401,00	196,24	N.D	N.D	102,30	1,10
P24	25,80	6,98	1744,00	N.D	48,00	50,60	689,30	112,22	54,96	175,00	16,00	244,32	55,78	N.D	0,03	38,36	1,50
P25	25,60	7,02	2150,00	N.D	55,00	73,40	677,10	20,84	165,38	210,00	8,00	401,15	72,09	N.D	0,01	34,20	0,90
P26	25,90	7,00	2340,00	N.D	55,00	73,40	677,10	152,30	96,30	265,00	4,00	450,85	100,30	N.D	0,01	51,56	1,10
P27	25,80	6,91	2820,00	N.D	58,50	87,80	720,00	140,28	123,55	310,00	4,00	531,91	49,96	N.D	0,02	22,33	0,90
P28	25,80	6,86	2340,00	N.D	56,00	75,00	689,30	57,71	147,38	250,00	2,00	425,90	115,02	N.D	0,01	37,47	0,80
P29	25,30	6,94	2413,00	N.D	62,00	76,34	762,50	67,92	144,31	231,00	4,00	386,71	195,00	N.D	N.D	24,00	0,90
P30	25,90	7,24	1772,00	N.D	46,00	60,60	567,30	117,03	76,36	175,00	2,00	312,04	61,75	N.D	0,01	23,39	1,10
P31	25,90	7,31	1668,00	N.D	47,00	58,40	579,50	109,02	75,88	165,00	3,00	276,90	67,45	N.D	N.D	20,38	0,90
P32	25,90	7,60	1806,00	N.D	48,50	60,00	597,80	92,98	89,49	185,00	2,00	280,45	59,34	N.D	N.D	31,72	0,80
P33	25,70	6,86	2530,00	N.D	61,00	41,60	750,30	121,00	27,72	41,43	7,00	429,55	120,12	N.D	N.D	40,24	0,50
P34	25,80	6,89	2350,00	N.D	61,50	36,00	756,40	77,34	40,37	46,90	3,00	404,12	98,40	N.D	N.D	38,10	0,58
P35	25,90	6,97	1921,00	N.D	42,00	69,60	518,50	133,06	88,52	165,00	2,00	395,00	85,10	N.D	0,06	21,13	1,50
P36	25,90	7,35	2960,00	N.D	54,50	111,20	671,00	75,35	224,72	250,00	18,00	486,88	129,00	N.D	0,01	75,22	1,50
P37	25,90	6,99	1776,00	N.D	35,00	44,00	433,00	32,87	87,07	215,00	2,00	356,04	69,24	N.D	0,01	14,27	1,50
P38	26,00	7,07	1769,00	N.D	44,50	58,80	549,00	72,14	79,28	195,00	1,00	326,24	40,80	N.D	0,01	8,46	1,40
P39	26,00	7,51	3420,00	N.D	49,00	93,80	604,00	42,49	202,34	250,00	1,00	544,68	180,30	N.D	0,04	17,23	1,50
P40	26,00	7,01	2500,00	N.D	53,00	95,40	652,70	148,30	142,51	210,00	1,00	418,90	122,40	N.D	0,00	147,78	1,40
P41	25,46	8,34	2826,00	N.D	60,26	78,68	746,07	102,13	129,85	235,36	3,91	467,34	153,95	N.D	0,26	93,18	0,91
P42	25,27	8,12	1776,00	N.D	35,00	44,00	433,00	33,00	87,00	215,00	2,00	356,00	69,00	N.D	N.D	14,00	0,60

N.D: No Detected.

3.1. Temperature (T°C):
Temperature is an important biologically significant factor, which plays important role in the metabolic activities of the organism. The temperature ranged from 24, 30°C to 27°C during the study period. Lowest water temperature (24, 3°C) was observed in the well P11 and highest temperature (27, 0°C) value was observed in the well P13.

3.2. Electrical conductivity (EC) in µs/cm:
Electrical conductivity values vary between 527µs/cm and 10790µs/cm (Fig.1). Normal groundwater has a range of 100 to 2000µs/cm [11]. The values of electrical conductivity except for the wells P12, P15, P18, P20, P23, P27, P36, P39, P41, wich are exceeding the standards values it reflects the ability of an aqueous to conduct electrical current. It (signifies) means the amount of total dissolved salts [12]. EC is an important parameter in assessing water quality for drinking and irrigation purposes. EC is used as an indicator and classification of salinity. High values of EC in ground water are due to high dissolved solids. Therefore high EC means high degree of salinity and an index of the amount of dissolved substances in water [13].

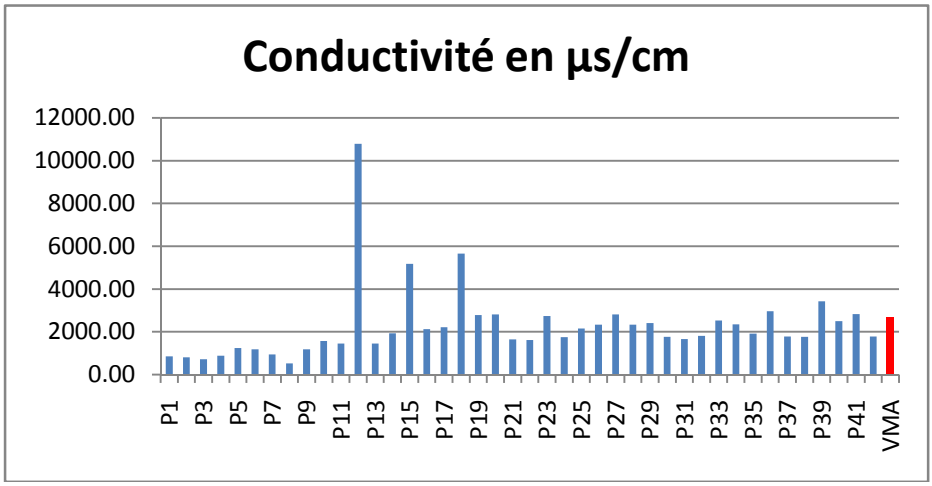

Figure. 2: Variation in the conductivity of the different samples

3.3. pH:
The pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. Most of the water samples are slightly alkaline due to presence of carbonates. The pH of groundwater is influenced by the geology of catchment area and the buffering capacity of water [8]. The pH values of water samples varied between 6,86to 8, 34 and were found within the limit prescribed by WHO [1].

3.4. Chloride (CL-) in mg/l:
In the present analysis, chloride concentration was found in the range of 82,00mg/l and 3631mg/l (fig.2), but two wells (P12, P18) have levels exceeding the standards values. Almost all the wells were far below the recommended WHO chloride level in drinking water. This again implies that all the waters studied were all of satisfactory quality in terms of their chloride contents and that chloride doses not contribute to problems of taste in some of the waters. The chloride concentration serves as an indicator of pollution. The waters rich in chlorides are laxative and corrosive (Humbert and Pommie, 1988 in Tarik, 2005). The concentration of chlorides in the waters also depends on the traversed terrain. People accustomed to higher chloride in water are subjected to laxative effects [14].

3.5. Total hardness TH in (°F):
Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. TH values for the wells studied show no major difference from one well to the other. They vary between 17, 50°F and 112, 80°F, respectively recorded at the wells P8 and P15. Based on these on these results, the groundwater in the area are generally hard. This hardness is the result of limestone and magnesium terrain crossed by water.

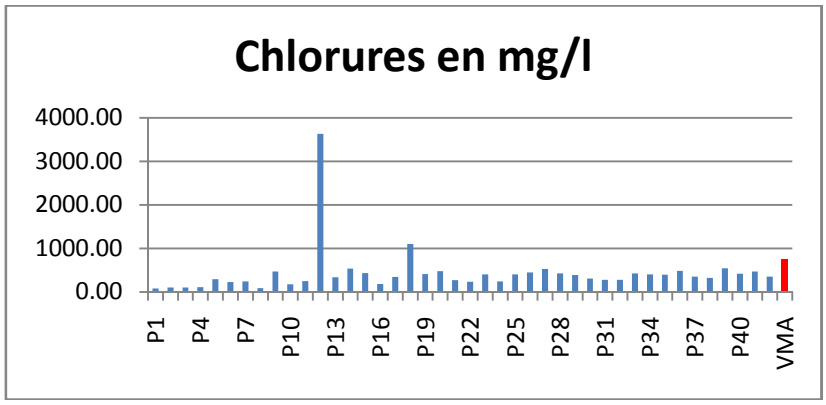

Figure 3: Variation in the chloride of the different samples

3.6. Sulfate (SO42-) in mg/l:

The sulfate naturally present in water, very variable concentration (major in contact with gypsum or and other common minerals) [15]. Discharge of industrial wastes and domestic sewage tends to increase its concentration. For all samples analyzed, the sulphate level was in the range of 8, 95 to 622,56mg/l (fig.3). P3 had the least sulfate level while P18 had the highest sulfate level that exceeds standard's value. The mean sulfate level value for all analyzed samples was 108, 26 mg/l. Almost all result confirms the acceptability of this groundwater in terms of their sulfate contents.

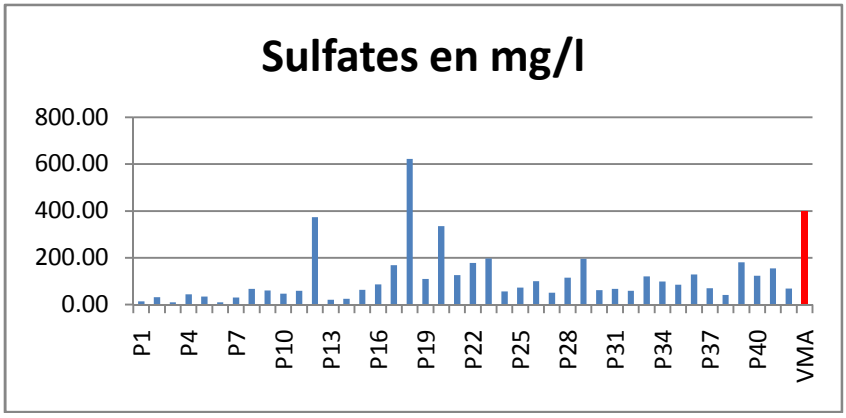

Figure 4: Variation in the sulfate of the different samples

3.7. Total alkalinity (TA)in (F°):

Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. This parameter (Total Alkalinity (TA)), is of no large difference from one well to another in the studied area, it oscillates between 14, 00°F (P8) and 63, 00°F (P23).

3.8. Calcium (Ca_2^+) in mg/l:

Calcium is a soft gray alkaline earth metal which is directly related to hardness. Calcium concentration ranged from 20, 84 to 178, 56 mg/l, respectively observed in spring P25 and P5. Mean value is 85,71mg/l.

3.9. Magnesium (Mg_2^+) in mg/l:

This is one of the most abundant elements in nature and it is a significant member in water hardness, it gives an unpleasant taste to water [16].Magnesium content in the investigated water ranging from 27,72mg/l (P8) to 231, 04 mg/l (P15), with mean value 90,38mg/l.

3.10. Nitrates (NO3-) in mg/l:

The nitrate concentrations varied between 0, 15 mg/l and 173mg/l with 21, 43% wells that exceed the standard's maximum allowable value (standard) (fig.4). Nitrogen is a naturally occurring element that is essential for the life of plants and animals. Low levels of nitrogen are normal in groundwater and surface water. However, elevated nitrate caused by human activity is pollutant in the water. Nitrate enters groundwater from many

sources, including nitrogen-rich geologic deposits, wild-animal wastes, precipitation, septic system drainage, feedlot drainage, dairy and poultry production, municipal and industrial waste, and fertilizers [17].

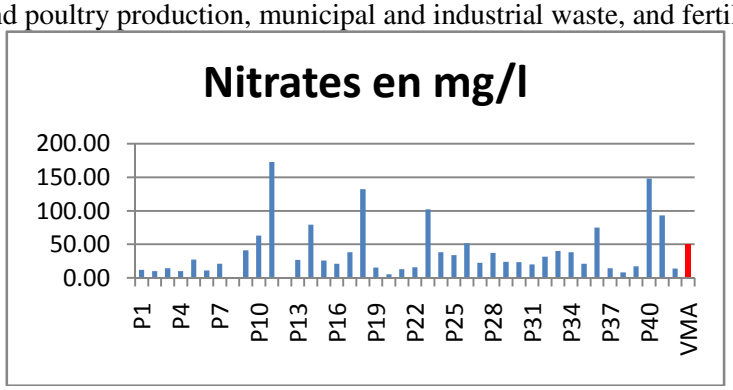

Figure 5: Variation in the nitrates of the different samples

Conclusion

The assessment of water quality is an important factor in the assessment of pollution levels. This study revealed that the water in the studied area is suitable for drinking and other domestic purposes in 67% of wells at the physicochemical level. The results, compared with Moroccan standards, showed 33% of wells exceed the recommended value for conductivity, which 5% of all wells exceed for assessment of microbial analysis of the studied area, should be carried out, as this would be helpful in early detection of any future degradation in order to fight against water-borne diseases.

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