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Microbacteriology Assessment of Groundwater from Hand Dug Wells in Igbo-Ora, Ibarapa Central Local Government Area, Oyo State, Southwestern Nigeria

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Abstract- Microbacteriology is bacteria found in water tapping from the weathered geologic formation (the regolith aquifer) which are thermo tolerant. This study assesses the microbacteriological characteristics of groundwater in Igbo-Ora, Ibarapa Central Local Government Area Oyo State, Southwester Nigeria. Three bacteriology contents were determined and they are Escherichia coli, Protues mirabilis and Klebsiella pneumonia. There was a significant bacteriological contamination in the wet season but not in the dry season. Seventeen wells showed evidences of sewage contamination, as the feacal coliform count (fc/ml) were higher than SON acceptable limit except in few locations. From the study, 18% of the wells excellently yielded water for residential/domestic purpose, thus indicating the possibility of water scouting, even in the wet season. Alternative water sources for public use are thus recommended. Disinfection is recommended for water drawn from wells due to sewage contamination tendencies, especially during the wet season.

Keywords- *Regolith Aquifer, Bacteriological Characteristics, Correlation Analysis, Feacal Coliform Count*

I. INTRODUCTION

Microbiological groundwater contamination occurs more easily in aquifers, in which permeability arises from fractures and karst phenomena [1]. In these aquifers, water can move quickly, allowing transport of microorganisms, with insignificant interaction between these microorganisms and the host rock. In porous aquifers, such as gravel or coarse sand aquifers, permeability results from pore space between grains. In this case, although the microorganisms can be easily transported [1], they also undergo interaction with the sand-gravel matrix, which can reduce pollution loads. To understand the dynamics that control the pathogenic contamination of groundwater, diverse factors must be taken into account. Both survival and persistence of microorganisms in groundwater are influenced by climate, rainfall, and temperature; such influences are particular to the microorganism involved [2, 3]. Meanwhile, the transport and the fate of such microorganisms can be determined by the hydrogeological characteristics of the aquifer [4, 5, 1, 2]. Furthermore, phenomena that regulate aquifer recharge (e.g., heavy rainfall), outflow, and discharge processes, as well as seawater intrusions, all affect microbiological pollution and make this issue difficult to manage [4].

Currently, it is well recognized that failure to protect groundwater sources, along with inadequate water treatment, are the primary reasons for bacterial contamination of drinking water [6]. In Italy, few studies dealing with the microbiological pollution of groundwater have been carried out [5, 7, 8], despite increasing risk. Although public health authorities have strong regulations about the distances between human and animal waste disposal sites and drinking water wells, with the intent to protect human health, they neglect any hydrogeological assessment [1].

In aquifers of Uganda [9], high concentrations of foecal pathogens to be associated with domestic wastewater and presence of sedimentary rocks have been reported. Other authors [10] have linked the use of manure in agriculture and soil type with high levels of coliform in groundwater in limestone/dolostone rock soils in areas of Canada and Zimbabwe. In the UK, first time evidence for the depth and extent of microbiological contamination of groundwater deriving from sewage pollution in two types of sandstone aquifers in Birmingham and Nottingham has been presented [11]. In Yemen, E. coli concentrations of up to 106 CFU/mL have been found in alluvial aquifers [12].

It is known that FE are more resistant than coliforms in natural environments, and that they can be an indicator of foecal contamination [13] and of resistance due to clostridial spores, which allows them to survive for long periods of time. It should be noted that some studies have reported pathogenic bacteria at a depth of 36 m [14] and others [11] at 91 m in confined aquifers. In Algeria, seven areas where wastewater was discharged without treatment have been evaluated, to find well water samples with foecal coliform up to 210 CFU/mL [15]. Other authors have concluded that the main source of pollution in Kampala (Uganda) is local surface discharge and wastewater [9], as well as by the presence of latrines, which are sites of frequent foecal waste disposal in developing countries.

A study conducted in Nebraska (USA) has determined that the wells located within 30 m of a septic system with water depth below 14 m show very high vulnerability to microbiological and chemical contamination [16].

Escherichia coli (E. coli) is the faecal indicator of choice used in Guidelines for Drinking Water Quality [17, 18, 19] and several countries acknowledge this organism as the primary indicator of faecal pollution. E. coli is almost exclusively derived from the faeces of warm-blooded animals and its presence in drinking-water is interpreted as an indication of recent or substantial post-treatment faecal contamination or inadequate treatment [20, 21, 22]. Thermo-tolerant coliforms include E. coli and also some types of Citrobacter, Klebsiella and Enterobacter. Although, thermo-tolerant species other than E. coli can include environmental organisms. Populations of thermo-tolerant coliforms detected in most waters are predominantly composed of E. coli. As a result, thermo-tolerant coliforms are regarded as a less reliable but acceptable indicator of faecal pollution [23].

In using E. coli or thermo-tolerant coliforms as an indicator of faecal pollution, a number of issues need to be considered. First, although E. coli does not readily grow outside the gut of warm-blooded animals in temperate regions, there is some evidence to suggest that it may grow in the natural environment in tropical regions. However, in most cases, E. coli would be out-competed by other environmental bacteria; therefore, whether growth occurs in nature is questionable. If such growth were to be found in certain tropical regions, then regulations would have to be based upon alternative indicators of post-treatment faecal contamination in storage and distribution systems, such as intestinal enterococci and Clostridium perfringens spores [24].

E. coli is extremely sensitive to disinfection. Its presence in a water sample is a sure sign of a major deficiency in the treatment or integrity of the distribution system. However, its absence does not by itself provide sufficient assurance that the water is free of risks from microbes [25, 26]. Many viral and protozoan pathogens are significantly more resistant to disinfection and may survive exposure to disinfectant that inactivates E. coli. Ingress of sewage into distribution system conveying water with a disinfectant residual might not be detected using E. coli alone, as these bacteria might be inactivated while other pathogens remained viable [27, 28, 29].

Sangodoyin (1993) found microbes in groundwater close to sites of waste disposal in Abeokuta area, highlighting the potential for impacts from other pollutants. Orebiyi et al, 2007 [30] carried out analysis of bacteriological quality of shallow well water of Abeokuta. Abeokuta was divided into four zones namely Indigenous areas (I), Peri-urban areas (P), modern low density areas (MLD) and modern high density areas (MHD) and a total of 40 shallow wells over the entire study area were investigated. The result of the bacteria count shows a minimum value of 20 col/100ml at MHD-1 and a maximum value of 800 col/100 ml. Fifteen of the wells also show presence of multiple bacteria. From the study, it was found that shallow well water in Abeokuta are highly contaminated with faecal bacteria and requires disinfection before use since all the wells test positive to the presence of faecal bacteria.

II. LOCATION OF THE STUDY AREA

The study area, Igbo-Ora, is the headquarters of Ibarapa Central Local Government Area of Oyo State, Southwest Nigeria. The town is located between longitudes 3°13`Em and 3°19`Em and latitudes 7°22`Nm and 7°28`Nm. Approximately, as the crow flies, Igbo-Ora is 66km north-west of Ibadan, the Oyo State capital and about 32km north of Abeokuta, the capital of Ogun State. Igbo-Ora share boundary with Ogun state to the South and West, Ibarapa North Local Government Area to the North-West, Iseyin Local Government Area to the North-East and Ibarapa East Local Government to the East (figure 1).

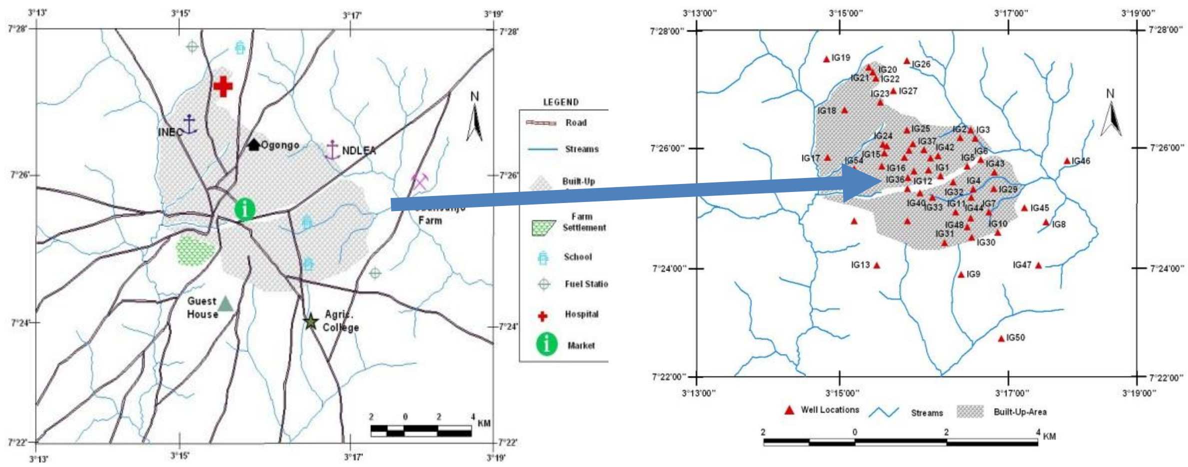

Figure 1. Digitized and spatial location map of well in the study area

A. Groundwater flow Direction

Figure 2 shows the direction of groundwater flow in the study. Groundwater predominantly flows out of the study area through the Northwestsern side as evidenced by the flow towards INEC office. The flow towards the L.G.A Guest House is a flow in the southwestern direction, while in the northeast direction, groundwater flow towards Obasanjo farms. Groundwater flow towards College of Agriculture was also noticed, as well as groundwater flow away from Resort centre towards NDLEA office. The places from where groundwater flow includes: Resort Center, Ogongo, Express-Igbole, Odeyale-pako, Gbotikale, General Hospital and Bambeke-Igbole, and they represent the recharge areas in the study.

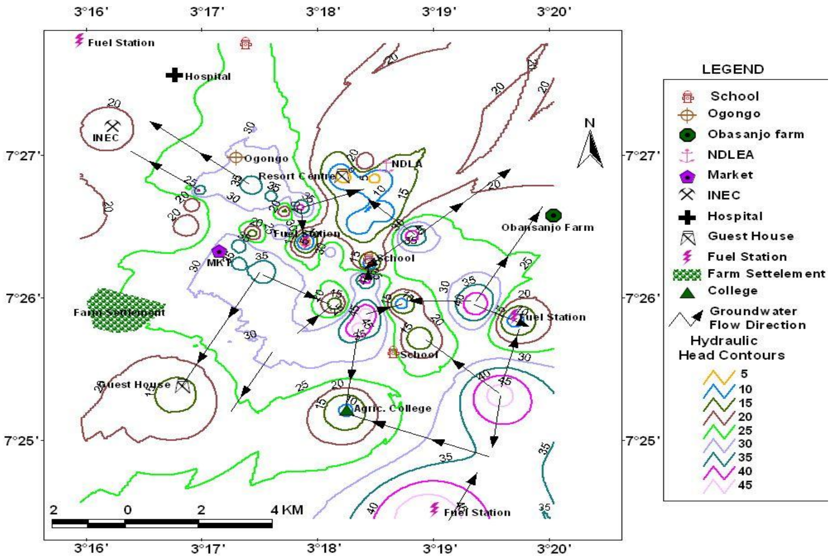

Figure 2. Groundwater flow direction of the study area

B. Methods

Microbiological contents were taken using standard membrane filtration techniques through a cellulose ester membrane and the results were confirmed by presence/absence of the bacteria in all samples collected. Groundwater information was collected using the handheld Global Positioning System (Garmin GPS). Information, such as geographic coordinates were obtained from 50 hand dug wells in dry and wet season and all was analysed. The hand dug wells were grouped according to their location and their bacteria identity. Three thermo-tolerant micro-bacteria were determined and they are Escherichia coli, Protues mirabilis and Klebsiella pneumonia. Grouping into risk categories was done and compared to the Standard Organization of Nigeria (SON) drinking water criteria [31]. This showed that E. coli being the major indicator of pollution.

C. Statistical Analysis

The microbiological data were exported for further analysis using (EVIEWS 11) statistical packages. The t-test correlation analysis was conducted to show the relationship between the thermo-tolerant studied. The Pearson 'r' table for the 50 sampled with the degree of wisdom of 48 at 0.01was 0.361 and were compared to the computed value which showed lower value to the computed (table 3).

III. RESULTS

Table 1 showed the results of bacteriological content of water samples collected for analysis in this study for dry and wet seasons. Laboratory analysis showed the presence of one or two of Escherichia coli, Protues mirabilis and Klebsiella pneumonia and their Number of count per milliliter were determined. In dry season, 34 wells out of 50 showed absence of microbiological contents in water sampled. Eleven (11) wells showed presence of Escherrichia Coli (E. Coli.) and it a value ranges from 10-65. Two (2) wells showed the presence of Proteous mirabilis (PM) and its value ranges from 30-50 No/ml. other 2 wells howed the presence of Klebsiella Pneumonia and it value is (30 and 40) No/ml. only 1 well showed the presence of both Proteous mirabilis and Escherrichia Coli (E. Coli.) and its value is 50 No/ml. In the wet season, seventeen (17) wells out of 50 showed absence of microbiological contents in water sampled. Twenty five (25) wells showed presence of Escherrichia Coli (E. Coli.) and it a value ranges from 2-73 No/ml. One (1) well showed the presence of Proteous mirabilis (PM) with value of 50 No/ml. Two (2) wells showed the presence of Escherrichia Coli (E. Coli.) and Klebsiella Pneumonia and it value is (30 and 40) No/ml. Five (5) well showed the presence of both Escherrichia Coli (E. Coli.) and Proteous mirabilis (PM) and its value ranges from (3-72) No/ml. 32% of the studied wells showed evidences of contamination while 68% were not infected.

TABLE I. BACTERIOLOGICAL CONTENT OF WATER SAMPLES

S/NO	Name of Location	Dry Season Result		Wet Season Result	
		No/ml	Bact. Id	No/ml	Bact. Id
1	Owotutu HQ.	0	-	8	EC
2	Resort Center	0	-	0	-
3	NDLEA	0	-	0	-
4	Adegoke N/PS	0	-	4	EC
5	Akin Akintola	0	-	10	EC
6	Ogboja	0	-	0	-
7	KSTD-Igbole	40	EC	50	EC
8	Owotutu-Igbole	20	EC	35	EC
9	College Of Agric.	0	-	0	-
10	Moore	0	-	5	EC
11	Okunrin-Rodo	0	-	4	EC
12	Adebisi-Idofin	0	-	2	EC
13	L.G.A.-Guest House	0	-	10	EC
14	Agba-Akin Idofin	0	-	8	EC
15	Afonja	0	-	0	-
16	Isale Oba (R.A)	0	-	3	PM + EC
17	Oke-Ayin Gramm. Sch.	40	PM	55	PM+EC
18	INEC	30	PM	38	PM
19	Owotutu Idere Rd.	20	EC	30	EC
20	Olugbon M.C.	10	EC	15	EC+PM
21	General Hospital	0	-	0	-
22	Owotutu Farm	0	-	0	-
23	Mechanic W.S.	0	-	20	EC
24	Isale-Ajegunle	0	-	4	EC
25	Ogonbo Oke-Iserin	0	-	3	EC
26	Lajorun H.S. Oke-Iserin	0	-	0	-
27	Igbo-Tapa	0	-	6	EC
28	VET-Clinic	0	-	4	EC
29	Ajibade's House	0	-	0	-
30	Methodist Sch.11	0	-	0	-
31	RCCG Iberekodo	60	EC	70	EC+PM
32	Oduremi Pako	40	EC	45	EC
33	Elejire Iberekodo	0	-	0	-
34	Olu-Asho Iberekodo	0	-	0	-
35	Towobowo Market	65	EC	72	EC+PM
36	Ojenike Sagan-un	60	EC	66	EC
37	Onikeke	0	-	0	-
38	Baptist Pry-Sch	0	-	0	-
39	Ile-Elegun	0	-	6	EC
40	Ile ArisanyaN	0	-	0	-
41	Ile Agbagbatele	60	EC	73	EC
42	Agborikura Iberekodo	50	PM + EC	65	EC
43	Odeyale Pako	0	-	50	EC
44	Adedokun	0	-	0	-
45	Bambeke Igbole	40	KP	43	EC+KP
46	Obasanjo Farms	30	KP	35	EC+KP
47	Express Igbole	0	-	0	-
48	Sawmill	0	-	7	EC
49	Gbotikale	40	EC	47	EC
50	Shammans	20	EC	30	EC

Source: Field Survey

On the other hand, in the wet season 66% showed evidences of contamination while only 34% were free from contamination. Figure 1 showed Variation of faecal colliform in water sample for both season in comparison with SON standard limits (table 2). Table 3 showed the correlation coefficient matrix of the thermo-tolerant bacteria studied. The result showed that wet season have positive and strong correlation with the dry season with (r = 0.944).

TABLE II. STANDARD ORGANISATION OF NIGERIA MICROBIOLOGICAL LIMITS FOR DRINKING WATER QUALITY

Parameter	Unit	Maximum permitted levels	Health Impact
Total Coliform count	Cfu/mL	10	Indication of faecal contamination
Thermo tolerant Coliform or *E.coli*	Cfu/100mL	0	Urinary track infections, bacteraemia, meningitis, diarrhae, (one of the main cause of morbidity and mortality among children), acute renal failure and haemolytic anaemia
Faecal streptococcus	Cfu/100mL	0	Indication of recent faecal contamination
Clostridium perfringens spore	Cfu/100mL	0	Index of intermitted faecal contamination

Source: [31]

TABLE III. CORRELATION COEFFICIENT MATRIX BETWEEN DRY AND WET SEASON

Seasonal Thermo-tolerant	Dry_Season	SON	Wet_Season
Dry_Season	1		
SON	NA	NA	
Wet_Season	0.944*		1

* represents 1% significant level at 2 tailed

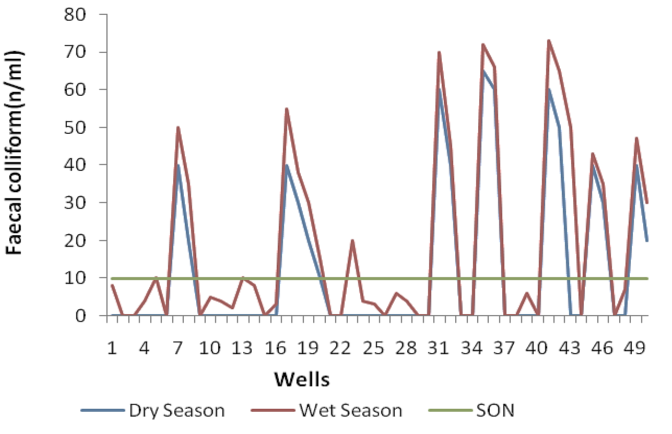

Figure 3. Variation of faecal colliform in water sample for both season in comparism with SON limits

IV. Discussion of Results

From the results of the study, 32% of the tested wells showed evidences of contamination in the dry season while it doubled in the wet season as they contained more of Escherichia coli, Proteous mirabilis and Klebsiella pneumonia. Graphical comparison of the observed bacteriological content of samples for dry and wet season showed that 34% of the wells were evidently contaminated as they have values of feacal coliform count above 10No/ml; the threshold set by Standards Organisation of Nigeria. This suggests the presence of sewage or improperly managed waste disposal system around the infected wells and the implication of which is urinary tract infections, bacteraemia, meningitis, diarrhea, acute renal failure and haemolytic anaemia. In the dry season 32% of the tested wells showed evidences of contamination while 68% were not infected at all. On the other hand, in the wet season 66% showed evidences of contamination while only 34% were free from contamination. The results also showed that Escherichia coli (E. coli) were the major indicator of water pollution in the dry with eleven (11) wells contaminated with high value of 65 No/ml and twenty five (25) wells contaminated with high value of 73 No/ml in the wet season. Using Pearson correlation statistic (‘r’), at 99% confidence level interval, seasonal variation were analyzed and significant differences were found to exist for bacteriological content of water samples between dry and wet seasons which showed high content of bacterial in the water sampled. High correlations show that the parameters are derived from the same source [32].

V. CONCLUSION

This study revealed that the hand dug wells tested Igbo-Ora, Ibarapa Central Local Government Area, Oyo State, South-west Nigeria are vulnerable to microbiological contamination due to risk factors such as human activities, lack of well protection structures and the hydrogeological characteristics in the area. Health wisely, recognising this vulnerability is crucial in areas where groundwater is the main source of drinking water. Wells with high coliform count were indicators of high organic loads and indices of pollution from leachates, seepages from waste disposal system within well vicinity and infiltration into storage from run-off which was more evident in the wet season. From the results of the bacteriology contents, it showed that local soil characteristics, most especially filtration capacity can promote or hinder microbiological water pollution. Climate characteristics, especially rainfall frequency, as well as human activities that involve any extensive use of water resources, influence the level of groundwater contamination, leading to reduced water availability and to progressive deterioration of its quality. A multidisciplinary approach is required in identifying the measures necessary to protect our groundwater resources by the management concern. It is also recommended that adequate solid waste disposal system be adopted, waste deposit or discharge on identified recharge points be avoided. Finally, water drawn from hand dug wells should be boiled before consumption, since conventional water treatment plants may be too expensive for individual families.

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VI. APPENDIX

TABLE IV. LOCATION, GEOGRAPHICAL COORDINATES AND HEIGHT OF STUDIED WELLS IN THE STUDY AREA

S/NO	Well Location	Latitude	Longitude	Height above mean sea level (m)
01	Owotutu (HQ)	7.4386389	3.2963333	173
02	resort center	7.4460000	3.3000000	194
03	NDLEA office	7.4458333	3.3028611	156
04	Adegoke NPS	7.4360833	3.3024444	162
05	Akin-Akintola	7.4405278	3.3013611	182
06	Ogboja	7.4418056	3.3038611	163
07	Kastad Igbole	7.4316944	3.3054167	167
08	Owotutu Igbole	7.4298611	3.3162222	172
09	College of Agric.	7.4197778	3.3001944	141
10	Moore fuel station.	7.4278333	3.3070833	158
11	Okunrin-Rodo	7.4316667	3.2991944	167
12	Adebisi-Idofin	7.4395833	3.2912778	166
13	lga guest House	7.4215556	3.2842500	160
14	Agbaakin-idofin	7.4421111	3.3243889	169
15	Afonja-Idofin	7.4430278	3.2856667	172
16	Isale-Oba(R.A)	7.4404722	3.2851944	156
17	Oke-ayin Grammar School	7.4421944	3.2750000	154
18	INEC Office	7.4513333	3.2782222	155
19	Owotutu (Idere RD)	7.4611389	3.2747778	154
20	Olugbon Med.	7.4585556	3.2835278	158
21	General Hospital	7.4594722	3.2827222	175
22	Owotutu Farm	7.4574167	3.2840556	162
23	Mechanic WS Ajegule	7.4528056	3.2849444	156
24	The blood Church. Ajegule	7.4447222	3.2853611	155
25	Ogongo Oke Iserin	7.4474167	3.3020278	177
26	Lagorun (H.S)	7.4607778	3.2899722	182
27	Igbo- Tapa	7.4550000	3.2873611	170
28	Veterinary Clinic	7.4421667	3.2894722	160
29	Ajibade's House	7.4362500	3.3063611	175
30	Methodist School II	7.4269167	3.3021389	164
31	RCCG IB Erekodo	7.4258611	3.2970278	160
32	Oduremi Pako	7.4375278	3.2986944	178
33	Elejire Iberekodo	7.4345556	3.2948056	176
34	Olu-asho Iberekodo	7.4436111	3.2903333	175
35	Towobowo Market	7.4397778	3.2940278	173
36	Sagaun (Ojenike)	7.4362500	3.2900000	168
37	Onikeke (Oke- Isimin)	7.4436667	3.2931667	170
38	Baptist Pry School	7.4448056	3.2910833	170
39	Ile-Elegun	7.4383333	3.2901667	163
40	Ile-Arinsanyan	7.4353889	3.2924444	155
41	Ile-Agbagbatele	7.4444167	3.2861667	172
42	Aborikura (IBKD)	7.4425000	3.2958333	179
43	Odeyale Pako	7.4393333	3.3064167	170
44	Adedokun	7.4345278	3.3021111	170
45	Bambeke Igbole	7.4316111	3.3125833	173
46	Obasanjo Farm	7.4415556	3.3201667	139
47	Express Igbole	7.4214722	3.3147778	159
48	Sawmill	7.4288889	3.3013611	160
49	Gbotikale	7.4305556	3.3020278	174
50	Ahamans Pet.	7.4075000	3.3077778	174

Abbreviation

Count = no per ml
0 = no growth
EC = Escherichia coli
PM = Proteous mirabilis
KP = Klebsiella pneumonia