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THE NEED FOR NEW MICROBIOLOGICAL WATER QUALITY CRITERIA

The microbiological criteria for water quality were established such as to protect consumers from possible microbiological pollution which may cause public health hazards. Therefore, the bacteriological standards for drinking water are based mainly on bacterial indicators. Another problem of prime concern to public health is the presence of antibiotic-resistant bacteria in drinking water.

Antibiotic-resistant bacteria were found among standard plate count population of chlorinated drinking water from two districts in Cairo. Most strains (89%) appeared to be ampicillin-resistant. Those were followed by sulfaguanidine-resistant (78%) and streptomycin-resistant (57%) ones. The majority of the strains tested were resistant to two or more antibiotics (multiple antibiotic-resistant, MAR) which represent 62.4 to 98% of the total isolates. Identification of 363 MAR strains revealed that Gram-positive rods were dominant. Gram-negative fermentative rods, Gram-positive cocci and Gram-negative nonfermentative rods represent the second, third and fourth group of the identified MAR phenotypes.

A total of 101 isolates (non-fecal coliform) from underground water pumped from three water plants in Cairo were classified in genera or groups according to their morphological, cultural and physiological characters and their resistance to four commonly used antibiotics (chloramphenicol, tetracyclin, neomycin, penicillin) and one chemotherapeutic agent (sulfanilamide pyrimidine) was tested. Results showed that 77 and 64 isolates have acquired resistance to penicillin and sulfanilamide pyrimidine, respectively; 32 isolates were resistant to tetracyclin. Only 18 and 8 isolates were resistant to chloramphenicol and neomycin, respectively. It was also found that 19 isolates belonging to 6 genera or groups were sensitive to all compounds tested.

Therefore, any source of antibiotic-resistant bacteria must be investigated carefully and use of the data on MAR bacteria should be made in future deliberations about water quality and in regulation over the quality of effluents discharged.

1. INTRODUCTION

The microbiological criteria for water quality were established such as to protect consumers from possible microbial pollution which may cause public health hazards. Therefore, the bacteriological standards for drinking water are based mainly on total coliform, fecal coliform, fecal streptococci and heterotrophic bacteria densities [12].

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Another problem of prime concern to public health is the presence of antibiotic-resistant bacteria in drinking water. In recent years, the usage of low concentrations of antibiotics in animal feed to promote growth, and the geater emphasis by the medical professions on antibiotic therapy for treating a wide spectrum of bacteria polluting the environment, is frequently considered. Previous studies proved that inadequately treated sewage and wastes are the main sources of antibiotic-resistant bacteria in the environment. For example, the antibiotic resistance of 582 different bacterial isolates to 5 antibiotics was surveyed [18]. The author found that 57 isolates were drug-resistant and classified as Gram-negative bacteria. The strong drug-resistance of some isolates is suggestive of resistance factor (R factor) responsible for moderated resistance, none of the 57 drug-resistant isolates transmitted resistance to the sensitive recipients. The detection of antibiotic-resistant bacteria in water resources was studied by many investigators. Some of them [11] associated the isolation of antibiotic-resistant bacteria in streams with the degree of water pollution. It was reported [7] that the incidence of antibiotic-resistance among total and fecal coliforms reached more than 40% in potable water samples from the springs and wells tested, while it was increased to 60% in stream and seawater samples. The discovery that resistance characteristics can be transferred via R factor (resistance plasmid) to sensitive recipient cells has emphasized the magnitude of the problem [20].

The present investigation was undertaken to assess the number of antibiotic-resistant bacteria present in treated drinking water as well as in groundwater (untreated drinking water) in Cairo.

2. MATERIALS AND METHODS

2.1. SAMPLING OF TREATED SURFACE WATER AND MIXTURE OF TREATED AND GROUND WATERS

Drinking tap water samples were collected over a period of several months (September 1983 to March 1984) from two districts in Cairo, namely El-Dokki and Nasr-City. El-Dokki district receives its water from the El-Giza water treatment plant which is supplied with water from the River Nile. Raw water is flocculated and coagulated with alum, filtered through sand filters, chlorinated, collected in storage tank, chlorinated again and pumped into the distribution system, Nasr-City district receives its water from the Mostrod water treatment plant which is supplied with a mixture of raw water from the Ismailia Canal and underground waters.

The water from the Ismailia Canal is treated in the same way as the water from the River Nile in El-Giza water treatment plant.

Two water samples were collected in 1 dm^3 sterile plass bottles, each containing 1 cm^3 of 10% sodium thiosulfate. Samples were examined within 2 h of collection.

2.1.1. STANDARD PLATE COUNT (SPC) BACTERIA

Bacteria were counted as follows: suitable volume of a sample (50 and/or 100 cm^3) was passed through Sartorious membrane filters (GMbH, Gottingen, Germany) of 0.45 μm

pore size. Thereafter the filters were placed on m-SPC agar [22] and incubated for 48 h at 35°C. Bacterial colonies were counted using a binocularscope at 15 x magnification.

2.1.2. ANTIBIOTIC-RESISTANCE DETERMINATION

Nutrient agar (Difco) was used as a basal medium to determine antibiotic-resistance of the strains tested. Antibiotic-containing media were prepared by adding sterilized antibiotic solution to melted and tempered (48–50°C) nutrient agar. The antibiotics used and their final concentrations per cm^3 of the medium were as follows: ampicillin (15 μg), tetracycline hydrochloride (15 μg), chloramphenicol (25 μg), streptomycin sulfate (15 μg) and sulfaguanidine (350 μg).

To test their resistances to antibiotics, the colonies (50–100) were randomly selected from the m-SPC filters and inoculated onto m-SPC agar plates. After 48 h incubation at 35°C, the master plate colonies were replicated onto the medium containing antibiotics. Five antibiotic plates and one control plate containing no antibiotic were inoculated consecutively. Plates were incubated at 35°C for 24 h and antibiotic resistances of bacteria were determined. An organism was considered as resistant to an antibiotic if it grew on the antibiotic plate as well as on the control plate. Each sign of growth inhibition was scored as bacterial sensitivity to that antibiotic.

2.1.3. IDENTIFICATION OF MULTIPLE ANTIBIOTIC-RESISTANT (MAR) STRAINS

MAR strains to be identified were picked from the control plates and inoculated into nutrient broth (Difco). After incubation for 24 h at 35°C, a loopful of each culture was streaked onto nutrient agar (Difco). A single colony from each plate was used for identification. All strains were classified into genera or groups by determining colony and cell morphology, Gram-staining, catalase and oxidase reactions, motility, urease, indole and glucose fermentation or oxidation using schema of BUCHANAN and GIBBONS [6], LENNETTE at al. [15] and LeCHEVALIER et al. [14], respectively.

2.2. EXPERIMENTAL FOR UNDERGROUND WATER STUDY

Underground water samples were taken from 13 wells in three water treatment plants (Mostrod, El-Marg and El-Maadi) in Greater Cairo. Samples were aseptically collected from wells in sterile 1 dm^3 bottles and analysed within 4 h. Aliquots of 10 cm^3 were inoculated in test tubes containing 10 cm^3 of MacConkey broth medium (double strength). Acid and gas produced after 48 h at 37°C proved that coliforms were presented in test tubes. All tubes with coliforms were then inoculated in EC broth [9] and incubated in a circulating water bath for 24 h at 44.5 ± 0.1°C. Bacteria other than fecal coliforms, which could produce acid and gas at 37°C, but not at 44.5°C, were isolated from the inoculated MacConkey tubes. Bacterial strains representing different wells were isolated by streaking on Eosin Methylene Blue agar (EMB) and purified [16]. The strains were classified into genera or groups [14].

Resistance of bacteria to chloramphenicol, tetracycline hydrochloride, neomycin sulfate, penicillin G-sodium salt and 2-sulfanilamide pyrimidine was studied. Nutrient agar medium was enriched with the antibiotic tested to give final concentration of 50 μg of international unit/cm^3. Five plates with different antibiotics or the chemotherapeutic sulfadiazine were streaked in parallel raws with test organisms and incubated at 37°C for 48 h. Antibiotic resistance was determined by comparing growth on medium enriched with antibiotics with the corresponding control devoid of antibiotics.

3. RESULTS

Drinking water samples collected from two districts in Cairo were tested for presence of antibiotic-resistant bacteria. The antibiotics used for this investigation were selected to include those most commonly applied in therapy. It is emphasized that the antibiotic concentrations used for screening the resistant bacteria are the levels accepted as constituting clinical resistance [19].

Table 1

Percentages of antibiotic-resistant bacteria among SPC isolates from drinking samples

Source and date of sampling	SPC/cm^3	No. of strains examined	Percentage of isolates resistant to				
			Amp.[1]	Tet.[2]	Cm.[3]	Str.[4]	Sug.[5]
El-Dokki							
September 1983	38	163	57.4	9.5	16.7	20.9	54.4
October 1983	2	100	84	56	25	31	35
December 1983	2	100	94	74	6	12	75
January 1984	0.6	100	89	0	0	2	74
March 1984	0.4	100	96	27	9	12	100
Total		563	84	33.3	11.3	15.5	67.6
Nasr-City							
November 1983	1	50	80	78	12	74	80
December 1983	2	100	97	86	15	16	76
January 1984	1	97	84.5	0	0	94.8	56.7
February 1984	0.2	50	90	8	4	68	92
March 1984	3.4	100	97	6	1	32	86
Total		397	89.7	35.6	6.4	56.9	78.1

[1] ampicillin, [2] tetracycline, [3] chloramphenicol, [4] streptomycin, [5] sulfaguanidine.

The resistances to the antibiotics tested of 563 isolates from El-Dokki were arranged in the following ascending order: ampicillin > sulfaguanidine > tetracycline > streptomycin > chloramphenicol. A quite similar pattern was obtained for 397 isolates from Nasr-City. It was: ampicillin > sulfaguanidine > streptomycin > tetracycline > chloramphenicol (table 1). These observations may reflect very well the usage patterns of these antibiotics [21]. It is interesting to note that in January the bacterial resistances to tetracycline and chloramphenicol were 0.0% in the samples from both districts (table 1). Such a trend may be related to the low SPC population and/or to the limited diversity of species during the cold winter period [14].

Table 2

Percentages of bacterial isolates carrying different numbers of resistance determinants (R) isolated from drinking water samples

Source and sampling date	Percentage of strains carrying different numbers of R determinants*					Percentages of isolates
	1R	2R	3R	4R	5R	
El-Dokki						
September 1983	25.7	37.4	20.8	3.0	1.2	62.5
October 1983	10.0	34.0	35.0	18.0	1.0	88.0
December 1983	12.0	28.0	45.0	12.0	2.0	87.0
January 1984	18.0	75.0	2.0	0	0	77.0
March 1984	2.0	58.0	32.0	8.0	0	98.0
Sub-total isolates	14.9	45.4	26.2	7.6	0.8	80.0
Nasr-City						
November 1983	8.0	6.0	10.0	66.0	2.0	84.0
December 1983	2.0	28.0	53.0	16.0	0	97.0
January 1984	11.3	38.1	49.4	0	0	89.0
February 1984	0	34.0	58.0	4.0	0	96.0
March 1984	5.0	68.0	23.0	3.0	0	94.0
Sub-total isolates	5.5	38.5	39.7	13.6	0.2	92.0
% of total isolates	11.0	42.6	31.8	10.1	0.006	85.2

*Percentages are related to the number of isolates tested (see table 1).

Of the total screened antibiotic-resistant bacteria (960 strains isolated from water samples of both districts), the percentage of singly, doubly, triply, quadruply and quintuply resistant strains were: 11.0, 42.6, 31.8, 10.1 and 0.006, respectively. Thus, approximately 85% of these strains were considered as MAR (table 2).From comparison of resistance patterns it was evident that the percentage of the antibiotic-resistant strains carrying different numbers of resistant determinants (R) varied in the water samples from each district as well as between the samples of both districts (table 2). The percentage of strains carrying 1R, 2R, and 5R in the water samples from El-Dokki district were higher than those characteristic of Nasr-City. The percentages of MAR strains isolated from El-Dokki and Nasr-City water samples were 80% and 92%, respectively (table 2).

Table 3

Identities of some MAR strains isolated from drinking water samples

Identity	El-Dokki		Nasr-City	
	No. of isolates	% of total MAR	No. of isolates	% of total MAR
1.Gram-negative, nonfermentative rods		2.5		1.2
Acinetobacter spp.	1		0	
Alcaligenes spp.	3		0	
Moraxella spp.	1		0	
Flavobacterium spp.	0		2	
2. Gram-negative, fermentative rods		3.5		13
Aeromonas spp.	1		12	
Citrobacter freundii	1		3	
Enterobacter aerogenes/cloacae	4		6	
Hafnia	1		0	
3. Gram-positive cocci		1.0		8.6
Micrococcus spp.	2		14	
4. Gram-positive rods		93		77.2
Bacillus spp.	172		125	
Corynebacterium	15		0	
Total number of identified isolates	201		162	

The identities of some isolated MAR phenotypes (363 strains) are presented in table 3. Four major groups were identified according to Gram-staining, fermentative metabolism and cell morphology. Gram-positive rods constituted the largest portion of MAR phenotypes and represented 93% and 77.2% of the total identified strains isolated from El-Dokki and Nasr-City water samples, respectively. Gram-negative fermentative rods represented the second largest group, while the Gram-positive cocci and Gram-negative nonfermentative rods constituted the third and fourth groups of identified MAR strains.

A total of 101 isolates representing flora from 13 wells in three water works were purified and classified into genera or groups. The majority of isolates were found to belong to Gram-negative rods (47.52%), while only 8 strains (8.91%) were referring to Gram-positive rods. The classified strains were tested for their resistances to four antibiotics (chloramphenicol, tetracycline, neomycin and penicillin) as well as sulfanilamide pyrimidine. According to their resistances, bacterial isolates were divided into 3 groups (resistant to one antibiotic, resistant to more than one antibiotic and nonresistant strains).

Table 4

Antibiotic-resistance patterns for strains isolated from well water

Location	Antibiotic resistance*					No. of isolates	% of strains isolated from well
	Cm.[1]	Tet.[2]	Neo.[3]	Pen.[4]	Sulf.[5]		
Mostrod	–	–	–	–	–	7	31.8
	–	–	–	+	–	3	13.6
	–	–	–	–	+	3	13.6
	+	–	–	+	–	1	4.5
	–	+	–	+	+	3	13.6
	+	+	–	+	+	3	13.6
	+	+	+	+	+	2	9.1
El-Maadi	–	–	–	–	–	4	6.3
	–	–	–	+	–	11	17.4
	–	+	–	–	–	1	1.6
	–	–	–	+	+	29	46.0
	+	–	–	+	+	3	4.7
	–	+	–	+	+	4	6.3
	+	+	–	–	+	1	1.6
	–	+	+	+	+	4	6.3
	+	+	–	+	+	4	6.3
	+	+	+	+	+	2	3.2
El-Marg	–	–	–	–	–	8	50.0
	–	+	–	+	–	2	12.5
	–	+	–	+	+	4	25.0
	+	+	–	+	+	2	12.5

* – sensitive, + resistant.

[1] chloramphenicol, [2] tetracycline, [3] neomycin, [4] penicillin, [5] sulfanilamide pyrimidine.

Results recorded in table 4 summarize the antibiotic resistance of the isolated strains to the individual compound. It becomes evident that the majority of the isolated strains (63%) are characterized by multiple resistance ability towards two or more compounds (2R, 3R, 4R and 5R) (table 4). It is interesting to note that within a specific genus, some species (or strains) may be sensitive to the aforementioned antibiotics, while others belonging to the same genus can be resistant to one or more of these compounds. Most strains(76.23%) appeared to be penicillin resistant. These were followed by strains resistant to sulfanilamide pyrimidine (63.36%), tetracycline (31.68%), chloramphenicol (17.82%) and neomycin (7.92%).

Table 5

Antibiotic-resistance pattern for some strains isolated from underground water

Antibiotic resistance					R Det.	Number of isolates	Genera or groups
Cm.[1]	Tet.[2]	Neo.[3]	Pen.[4]	Sulf.[5]			
–	–	–	+	–	1	14	*Acinitobacter*(1), *Aeromonas*(1), *Flavobacterium*(1), *Bacillus*(2), *Moraxella*(2), *Pseudomonas*(7)
–	–	–	–	+	1	3	*Bacillus*(1), *Micrococcus*(1), *Moraxella* like group M (1)
–	+	–	–	–	1	1	*Micrococcus*(1)
–	–	–	–	–	0	19	*Aerobacter*(2), *Bacillus*(2), *Enterobacteriaceae*(1), *Micrococcus*(8), *Moraxella*(2), *Pseudomonas*(4)

+ resistant, – sensitive.

[1] chloramphenicol, [2] tetracycline, [3] neomycin, [4] penicillin, [5] sulfanilamide pyrimidine.

Table 6

Identities of MAR strains isolated from well water

Identity	Mostrod		El-Maadi		El-Marg	
	No. of isolates	% of total MAR	No. of isolates	% of total MAR	No. of isolates	% of total MAR
Gram-negative nonfermentative rods		0		63.8		0
Moraxella spp.	0		10		0	
Flavobacterium spp.	0		1		0	
Pseudomonas/Alcaligenes	0		19		0	
Gram-negative fermentative rods		33.33		19.1		62.5
Aeromonas	2		4		0	
Enterobacteriaceae	1		5		5	
Gram-positive cocci		55.55		10.6		37.5
Micococcus spp.	1		1		0	
Staphylococci	4		4		3	
Gram-positive rods		11.11		6.3		0
Bacillus spp.	1		3			0
Total MAR	9		47		8	

Results proved that 19 strains belonging to 6 genera or groups were sensitive to all the compounds tested, while the remaining isolates can be resistant to one or more of them. Only 18 isolates belonging to 7 genera and one group were resistant to one compound only, i.e. tetracycline, penicilline, or sulfanilamide pyrimidine (table 5).

The identities of the MAR phenotypes (64 strains) are presented in table 6. Four major groups were identified. Generally, Gram-negative nonfermentative rods constituted the largest portion of MAR phenotypes isolated from El-Maadi wells and represented 63.8% of the isolates. Gram-negative fermentative rods represented 33.3, 19.1 and 62.5% of the MAR isolated from Mostrod, El-Maadi and El-Marg wells, respectively (table 6). Gram-positive cocci represented 55.5, 10.6 and 31.5% of the MAR isolates from Mostrod, El-Maadi and El-Marg wells, respectively. Finally, Gram-positive rods represented 11.1 and 6.3% of the MAR isolates from Mostrod and El-Maadi,respectively.

4. DISCUSSION

The results of investigations clearly indicate that antibiotic-resistant bacteria are present among the populations tested. MAR strains prevailed among the isolates. Although the comparison of the percentages of resistant strains with those published by other researchers is quite difficult due to differences in type and concentrations of the antibiotics tested, our results are quite close to those reported by ARMSTRONG et al. [2]. They reported the presence of MAR isolates among SPC bacteria from drinking water of 6 communities in Oregon State, the U.S.A. The percentages reported by them ranged from 27.4 to 86.1% with an average value of 33.9%. Their investigations were similar to ours, because they also stated that the majority of MAR strains were resistant to two and three antibiotics.

The drinking water samples tested have a very low SPC (table 1) and the majority of MAR organisms are nonpathogenic (table 3). However, the presence of strains belonging to *Acinetobacter* spp., *Moraxella* spp. and *Flavobacterium* spp. could present a potential hazard to patients in hospitals, clinics, nurseries and rest homes ([9] and [13]). *Bacillus* spp., especially sporeformers, cause decaying of food products, beverages and spoiling of cosmetics and drugs [5], [10]. Such organisms may act as opportunistic pathogens [23] or may transfer their antibiotic resistance to other pathogenic microorganisms present in the intestinal tract of the consumer.

Our investigations concerning well water prove that among the isolated bacteria the majority (63.3%) are of multiple resistance ability towards more than one of the commonly used drugs in Egypt. Of the total screened antibiotic-resistant strains, the percentage of doubly, triply, quadruply and quintuply resistant strains were 31.68%, 14.85%, 12.87% and 3.96%, respectively. It is an interesting observation that within a specific genus, some species may be sensitive to some antibiotics, while others belonging to the same genus are resistant to one or more of these substances. In this respect, ARMSTRONG et al. [3] found that among the bacterial isolates from untreated river water in Oregon State, the multiple antibiotic-resistant bacteria were found to constitute 15.8 and 18.2% compared to 57.1 and 43.5% of MAR bacteria from the chlorinated clear well water on the same sampling dates. The same authors reported that chlorination of water during the treatment process could be responsible for a selection of antibiotic-resistant bacteria in the environment.

As a consequence of the development and proliferation of antibiotic-resistant bacteria, the therapeutic value of these drugs may be impaired. In this connection, our statement that the number of SPC isolates resistant to chloramphenicol were very low (table 1) must be considered carefully, since this antibiotic is the drug of choice for *Salmonella typhi* infections. Therefore every source of antibiotic-resistant bacteria must be tested thoroughly, and examination of data on MAR bacteria should be taken into account in the future water quality deliberations and in regulations of the quality of effluent discharges.

The present study proves that although the strains isolated are not pathogens, the probability of acquiring the multiple antibiotic resistance by pathogens, which in turn creates hygienic problems in modern society, should be considered.

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NOWE KRYTERIA MIKROBIOLOGICZNE JAKOŚCI WODY

Mikrobiologiczne kryteria jakości wody opracowano, aby chronić konsumentów przed ewentualnym mikrobiologicznym zanieczyszczeniem, mogącym stanowić zagrożenie dla zdrowia publicznego. Z tego względu normy bakteriologiczne dla wody pitnej są oparte przede wszystkim na wskaźnikach bakteryjnych. Innym ważnym dla zdrowia publicznego problemem jest obecność w wodzie pitnej bakterii odpornych na działanie antybiotyków.

Badano wodę chlorowaną pochodzącą z dwóch okręgów w Kairze. Bakterie odporne na działanie antybiotyków znajdowano w populacjach oznaczanych standardową metodą zliczania na płytce. Większość szczepów bakteryjnych (89%) była odporna na działanie sulfaguanidyny (78%) i streptomycyny (57%). Większość z badanych szczepów była odporna na działanie dwóch lub więcej antybiotyków (wielokrotna odporność na antybiotyki – MAR). Stanowią one 62,4–98% wszystkich wyizolowanych bakterii. Identyfikacja 363 szczepów typu MAR wykazała, że dominują pałeczki Gram-dodatnie. W zidentyfikowanych fenotypach MAR w następnej kolejności pojawiały się fermentacyjne pałeczki Gram-ujemne, ziarenkowce Gram-dodatnie i niefermentacyjne pałeczki Gram-ujemne.

101 szczepów bakteryjnych wyizolowanych z wody podziemnej pompowanej przez trzy stacje uzdatniania wody w Kairze podzielono na odpowiednie rodzaje lub grupy zgodnie z ich charakterystyką morfologiczną, kulturową (hodowlaną) i fizjologiczną. Zbadano odporność bakterii na działanie czterech powszechnie stosowanych antybiotyków (chloramfenikol, tetracyklina, neomycyna, penicylina) i jednego środka chemoterapeutycznego (sulfanilamid pirymidyny). Stwierdzono, że 77 wyizolowanych szczepów bakteryjnych wykazywało odporność na działanie penicyliny, 64 zaś było odpornych na działanie sulfanilamidu pirymidyny. Jedynie 18 wyizolowanych szczepów bakteryjnych było odpornych na działanie chloramfenikolu, 8 zaś – na działanie neomycyny. Stwierdzono również, że 19 wyizolowanych szczepów bakteryjnych było podatnych na działanie wszystkich badanych substancji.

Każde źródło bakterii odpornych na działanie antybiotyków musi być dokładnie zbadane. W rozważaniach na temat jakości wody do picia i jakości odprowadzanych ścieków należy wykorzystać informacje dotyczące szczepów bakteryjnych o wielokrotnej odporności na działanie antybiotyków (MAR).

НОВЫЕ МИКРОБИОЛОГИЧЕСКИЕ КРИТЕРИИ КАЧЕСТВА ВОДЫ

Микробиологичесие критерии качества воды были разработаны с целью предохранения пользователей перед возможным микробиологическим заражением, которое может составлять опасность для здоровья общества. Из-за этого бактериологические нормы для питьевой воды опираются прежде всего на бактериальные показатели. Другой важной для общественного здоровья проблемой является присутствие в питьевой воде бактерий, устойчивых к действию антибиотиков.

Исследована хлорированная вода, происходящая из двух районов в Каире. Бактерии, устойчивые к действию антибиотиков, находили в популяциях, обозначаемых стандартным методом сосчитывания на плитке. Большинство штаммов бактерий (89%) было устойчиво к действию ампицилина. По меньшей

степени они были устойчивы к действию сульфагуанидина (78%) и стрептомыцина (57%). Большинство исследуемых штаммов было устойчиво к действию двух или больше антибиотиков (многократная устойчивость к антибиотикам — МАР (MAR). Они составляют 62,4—98% всех выделенных бактерий. Идентификация 363 штаммов типа МАР обнаружила, что преобладают грамм-положительные палочки. В идентифицированных фенотипах МАР в следующем порядке появились ферментационные грамм-отрицательные палочки, грамм-положительные микрококки и неферментационные грамм-отрицательные палочки.

101 бактериальных штаммов, выделенных из подземной воды, перекачиваемой через три установки для подготовки воды в Каире были разделены на соответствующие роды или группы согласно их морфологической, культурной и физиологической характеристикам. Исследована устойчивость бактерий к действию четырех общеприменяемых антибиотиков (хлорамфеникол, тетрациклин, неомицин, пеницилин) и одного химиотерапевтического лекарственного средства (сульфаниламид пиримидина). Было установлено, что 77 выделенных бактериальных штаммов обнаруживали устойчивость к действию пеницилина, а 64 было устойчивыми к действию сулфаниламида пиримидина. Лишь 18 выделенных бактериальных штаммов было устойчивыми к действию хлорамфеникола, а 8 — к действию неомицина. Было также установлено, что 19 бактериальных штаммов подвергались действию всех исследуемых веществ.

Каждый источник бактерий, устойчивых к действию антибиотиков, должен быть точно исследован. В рассуждениях на тему качества питьевой воды и качества отводимых сточных вод надо использовать сведения, касающиеся бактериальных штаммов многократной устойчивости к действию антибиотиков (МАР).