**ISSN 0974-3618 (Print)**
**0974-360X (Online)**

**www.rjptonline.org**

***RESEARCH ARTICLE***

# Biochemical Study on the Removal of water Impurities using Modified Activated Carbon

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## ABSTRACT:
River and tap waters usually contain natural chemical and biological species known as impurities, whose composition changes from one location to another. Our investigation focuses on characterizing and removing water impurities using a column containing a mixture of powder and granular activated carbon impregnated with potassium permanganate to enhance the adsorption performance and to give it sterilization power. Four samples were subjected to different chemical and biological analysis. Two samples from Euphrates River, the first from a location near the city of Ramadi (RR0) and the second from a location near the town of Fallujah (FR0), where the river stream flows from Ramadi to Fallujah. Two other samples from tap water supplied by the municipality of Ramadi (RT0) and the municipality of Fallujah (FT0). The four water samples were allowed to pass once and twice through an activated carbon column (5 cm thickness), pre-treated with 0.1 w/w potassium permanganate solution. The samples were analyzed for various parameters such as pH, total dissolved solids TDS, chloride, phosphate, dissolved oxygen DO, electrical conductivity EC, turbidity, and bacterial existence. The analysis data indicates that the samples are not suitable to be used as drinking water due to the existence of high quantities of impurities. The treatment with activated carbon has some effects on the removal of chemical impurities and removes the bacteria found in one sample.

**KEYWORDS:** Tap water, river water, potassium permanganate, activated carbon, adsorption.

## INTRODUCTION:
Water is known to be the elixir of life as it represents the medium for the origin of organisms. The purity of water for human health has become an urgent and important issue, especially in recent years, where the levels of waters have fallen around the world. When water becomes contaminated, it becomes a serious threat to human life, so water purification has become essential for the continuation of life[1]. Water used for daily human consumption must be free of chemicals and organisms that have a dangerous role to play in various diseases, which causes damage to public health[2]. It was found that pollution of water around the world has reached a dangerous stage and the water quality is degrading[3].

Received on 02.09.2019 Modified on 17.09.2019
Accepted on 21.11.2019 
*Research J. Pharm. and Tech. 2020; 13(4):1790-1794.*
**DOI: 10.5958/0974-360X.2020.00322.4**

The chemical and physical properties of water depend on several variables such as location, dissolved minerals, depth of water pool, temperature, penetration of light, precipitations, pH and other variables[4-6]. Water contains natural organic matter which have a negative impact on the process of water treatment. The presence of such species causes some problems to the water and affect the odor, color and taste as well as inducing microbial growth[7]. The levels of natural organic matters in water sources increase significantly from year to year[8,9]. Water also contains dissolved minerals and salts as a result of the presence of water sources in areas containing these minerals and salts as well as the passage of this water in areas containing these elements. These minerals and salts are known as total dissolved solids TDS, which are a measure of the total content of inorganic and organic species found in water. The main ions are usually potassium, sodium, calcium, magnesium, chloride, carbonate, bicarbonate, nitrate, and sulfate[10]. Water with low TDS is considered to be insipid while with TDS more than 2000mg/L is considered to be unpalatable[1]. The low-level content of minerals in water is unsuitable

for human body health. The manufactured water is really demineralized water free from the necessary elements of the human body. A study conducted on the lack of minerals in drinking water revealed that there are some risks can be associated with the long term consumption of this type of water. These risks include kidney, gastrointestinal and bone density problems in addition to cardiovascular diseases[10]. In general, water containing minerals less than 300mg/L is defined as excellent, 300-600 good, 600-900 fair, 900-1200 poor and more than 1200mg/L unacceptable[10]. Water that is classified as drinking water is divided into two types; pure water and safe water. Pure water should be free from alien objects while safe may contain some contaminants that are not harmful to humans[11]. Water pollution has led scientists to find efficient and inexpensive ways to purify water, from these methods is the purification of water by treatment with activated carbon, as this method is considered effective and important for removing impurities, colors, odor and other biological species[12,13]. The huge pore sizes of activated carbon, high surface area and chemical stability make it an important adsorbent for many species and have a wide range of applications[14-16]. In order to improve the process of adsorption of impurities on the surface of activated carbon, studies have shown that impregnation with oxidizing materials such as potassium permanganate enhances its adsorption properties[17-19]. Potassium permanganate is one of the important antiseptic and oxidizing agents, which has the ability to destroy bacteria and work as antiparasites. It is often used in water treatment[20,21]. A study of different water resources at the global level was conducted by many groups of researchers[22]. Research study concerns the biological and chemical fetchers of polluted water have been discussed in detail[23]. A study on the removal of $Cu^{2+}$ ions from water using activated carbon modified by different concentrations of potassium permanganate showed that the adsorption process can be influenced by concentration and time, and no influence was observed for temperature[24]. The assessment of pH and total dissolved substances in the water samples purified as drinking water showed that the bottled water they examined is suitable for human consumption. The TDS they found was less than 100mg/L[25]. It was shown that the activated carbon modified with potassium permanganate is able to remove natural organic matters via the formation of complexes between the functional groups of its surface with the organic matters[26]. Several studies on the adsorption of different species from aqueous solutions using activated carbon have been carried out[27-29]. Other materials similar to activated carbon also used for such adsorption processes[30-32]. The object of the present research is to assess the performance of a mixture of powder and granular activated carbon modified by potassium permanganate on removing chemical and biological impurities from river and tap water.

## MATERIALS AND METHODS:

### Water Samples Collection and Apparatuses:

The collection of samples for testing was done with the utmost care because the sample should be representative of the water. The water samples used in this study were collected from the middle of the Euphrates River stream. One from a location near the city of Ramadi (RR0) and the other near the town of Fallujah (FR0). The tap water samples were taken from the water pipes supplied by the municipality of the city of Ramadi (RT0) and the municipality of the town of Fallujah (FT0). Both water samples (river and tap water) were collected in 2 liters nonreactive polypropylene plastic bottles. The bottles were cleaned with deionized water and sterilized before use. All samples were collected on 21st March 2019. All chemicals used in this work were of analytical grade obtained from Sigma-Aldrich. The pH was measured using a Philips (PW-9409) digital pH meter, the TDS was measured using TDS Smart Combined Meter 801, the quantities of chloride ion was calculated using the Mohr method, the quantities of phosphate ion was calculated at 882 nm using UV/Vis Spectrophotometer CE 7200, the DO was measured using HANNAHI9146-04, the electrical conductivity was measured using HANNA H12300, the turbidity was measured using HACH 2100N. Chemical and biological analysis was carried out in the Analytical Chemistry Laboratory and Biology Laboratory/College of Pharmacy.

### Modification of Activated Carbon:

The activated carbon used in this research is in powder and granular forms, and was modified by immersing each form separately in a 1% w/w potassium permanganate solution under neutral conditions. 10g of activated carbon were placed in a conical flask containing 100ml of 1% w/w potassium permanganate solution. The mixture was placed on a magnetic stirrer for 5 hours, after which the activated carbon was separated by filtrating through Whatman filter paper. The product was washed several times with distilled water until no color for the filtrate was observed, then dried in a furnace at 105˚C to constant weight in order to remove water and impregnation solution content.

### Experiment Design:

The filtration process was carried out using a filtration column composed of a layer of glass wool at the bottom of the column and above it a layer of powder activated carbon 2cm thickness and granular activated carbon 3 cm thickness, covered with filter paper. The four raw water samples RR0, FR0, RT0, FT0 were allowed to pass on the purification column once and were labeled RR1, FR1, RT1, FT1 respectively, and twice and were

labeled RR2, FR2, RT2. FT2 respectively. The purification experiment was carried out by passing 50ml of each water sample through the purification column, which was replaced by a new one for each set of the four samples for the purpose of exposing samples to the same conditions. The test was done at room temperature 25°C.

## RESULTS AND DISCUSSION:

The population of the world is increasing continuously and this increases the demand for water. The task of obtaining pure water is now one of the most important tasks that must be done by specialists. On the other hand, the water that is supplied to the house hold should be safe and free of any pollutants, whether chemical or biological. The parameters of the four main samples analyzed and the samples taken from them are summarized in (Tables 1, 2, 3, and 4)

**pH Measurement:**

The pH is a measure of how acidic or basic water is. Low pH water dissolves metals and other substances while high pH water causes a bitter tasteand decreases the chlorine disinfect action. The pH value of water is closely related to the presence of organic matter. High quantities of these substances lead to a reduction in pH because the degradation of organic matter leads to the formation of carbon dioxide. The acceptable range for the pH of water given in the WHO recommendations is between 6.5-8.5. The pH values of all the samples used in this research are around 7 and are well within the range. No significant effect of activated carbon on pH values was observed since the values were within the neutral range.

**TDS Measurement:**

Total dissolved solids or TDS is a measure of all solids dissolved in the water and can be calculated after evaporating a known quantity of water. TDS usually include carbonate, bicarbonate, chloride, fluoride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, and potassium. If other ion is present it will contribute to the total dissolved solid materials. Some other species may exist in water and contribute to the total, such as herbicides and humic acids. The obtained results for TDS in our research for all four raw samples RR0, FR0, RT0 and FT0 were above 700mg/L indicating that the water quality is fair according to the international standard. It is worth noting that the TDS values of the river water samples RR0 and RF0 are not different from those of the tap water samples RT0 and FT0, indicating that there is no treatment has been done on this water before it reaches the households. According to our investigation, the removal of minerals by the activated carbon modified by treatment with potassium permanganate was not significant, this is probably due to the short time of contact between water and activated carbon. The TDS values for RR0 and FR0 were 724 and 728mg/L respectively, reduced to 604 and 612mg/L for RR1 and RF1 respectively (removal efficiency about 17%). When the RR1 and RF1 samples were allowed to pass on the activated carbon column for another run to obtain RR2 and FR2 samples, the amount of TDS retained on the surface was also low, the values were 578 and 560mg/L for RR2 and FR2 respectively (total removal efficiency about 20%). The same discussion can be applied for RT and FT samples.

**Chloride Measurement:**

Chloride ion exists in water with sodium ion as NaCl and both elements are important to body life. $Na^+$ acts as major extracellular cation while $Cl^-$ acts as an extracellular anion. They act together to maintain acid-base balance and they regulate the osmotic pressure of bodily fluids. The accepted percentage of chloride in drinking water is supposed to be around 10mg/L and when this ratio exceeds 250mg/L the water taste becomes salty. The chloride quantities in the samples range from 17 to 33mg/L appear reasonable relative to the ratio of total TDS. The measurements showed that the content of chloride in the river and tap water samples of Fallujah town are twice that of the city of Ramadi, possibly due to the passage of water in areas near Fallujah, containing high quantities of this salts. A high concentration of chloride may indicate pollution due to organic waste. The activity of activated carbon to remove this salt is insignificant as shown in the tables.

**Phosphate Measurement:**

Phosphates are known to be nontoxic to people or animals if present at a moderate level, high levels cause digestive problems. It is one of the essential nutrients necessary for the nutrition and growth of living organisms in the water. The natural level of phosphate ions is usually between 0.005 to 0.05mg/L. Sometimes phosphates are added to the water to act as anticorrosive materials for the water pipes. In general, phosphates are existed as the thermodynamically stable orthophosphate and as the unstable polyphosphates which eventually convert to orthophosphate. The phosphates content of the samples is about 0.08 which seems acceptable for this type of water. This number didn't change clearly after passing samples on the purification column.

**DO Measurement:**

DO represents dissolved oxygen in water or it is the free, non-compound oxygen. The bonded oxygen of water is a part of the compound and it does not count toward DO level of water. It is an important factor in water quality due to its influence on the presence of organisms. The oxygen may be dissolved through diffusion from the surrounding environment (air or as a plant byproduct). A high DO level in water is preferable because it gives

drinking water good test. The DO levels in water vary from one type to another depending on water temperature, season, depth of water and some other factors. At high temperature and high salt level water has less dissolved oxygen. Animals and plant use DO for respiration. In industry, water with low levels of DO is preferable because high DO levels speed up corrosion in the water pipes. DO levels can range from less than 1 mg/L to more than 20mg/L. Healthy water should generally have DO content of about 6.5-8 mg/L. The DO content in the samples is well within range. This content near Ramadi city seems a little more than that near Fallujah town. No significant change was noticed for the DO values in the purified samples.

**EC Measurement:**

Electrical conductivity EC of water is defined as the ability of water to conduct an electric current. Salts or other chemicals that exist in water can break down into positively and negatively charged ions. These free ions in the water have the ability to conduct electricity. The electrical conductivity of the water depends on the concentration and quality of the ions found in the water as well as depends on the temperature. The results obtained for EC appear to be consistent with those representing TDS since the EC expresses the amount of salts exist in the sample. The highest values found in μS/cm for the raw samples became less after passing the samples through the purification column.

**Turbidity Measurement:**

Turbidity is the relative clarity of a liquid and for water, it is a measure of the light transmitting properties, or it is the amount of light that is scattered by material in the water. The greater the amount of scattered light, the greater the amount of materials present in the water and the higher the turbidity. Turbidity is caused by suspended materials in water, such as finely divided organic and inorganic materials, clay and other species. Usually, the turbidity is expressed as nephelometric turbidity units (NTU). Increased turbidity is usually accompanied by an increase in pathogen numbers, including cysts or oocyst. The turbidity of drinking water is supposed to go beyond 5 NTU, and should ideally be below 1 NTU. The present investigation showed that the turbidity values for the raw samples of the Euphrates River taken near the city of Ramadi and the town of Fallujah and the turbidity values of the tap water samples from the municipalities of both cities are not very different, again indicating that there is no clear treatment for the river water before it reaches the households. The turbidity values for RR0 and FR0 were 1.9 and 1.5 NUT respectively, and for RT0 and FT0 were 1.2 and 1.9 NUT respectively. After passing the samples through the purification column for two runs the values stabilized at 0.8 NUT indicating that the value is within the acceptable range.

**Bacterial Analysis:**

One of the most urgent consideration in assessing drinking water is bacterial quality. Bacteria and viruses are organisms causing disease and can be found in treated and untreated water. Coliforms are a type of bacteria naturally occurring in the environment and can be used as indicators for other harmful bacteria. *E. coli* and fecal coliform are bacteria caused by the contaminating of water by human or animal wastes. All these bacteria can be eliminated through treatment of water by chlorine UV light, chloramine and ozone. The water samples taken for testing were fresh and less than 24 hours old. The parameters for bacterial testing reveal that the RT0 sample was the only sample of the four main samples contained bacteria. The sample was analyzed for total viable counts (TVC, s), total coliforms (TC) and fecal coliforms (FC) using the most probable number[33] and the conventional methods[34]. Each analysis was repeated three times and the results showed the mean total viable counts was 95.7/10ml, the most probable number (MPN, s) of total coliforms was 820/10 ml and the most probable number (MPN, s) of fecal coliforms was 386.7/10ml. The bacterial content of the RTO sample appears to be low and it has been the result of passage of water in the transport pipes that are already contaminated with bacteria. The passage of the sample through the purification column removes all the bacterial existence.

**Table 1: The analytical values of the RR samples**

| Parameters/Samples | RRO | RRI | RR2 |
|---|---|---|---|
| pH | 7.2 | 7.5 | 7.4 |
| TDS mg/L | 724 | 604 | 578 |
| Chloride mg/L | 18 | 17 | 17 |
| Phosphate mg/L | 0.088 | 0.08 | 0.073 |
| DO mg/L | 7.03 | 6.89 | 5.89 |
| ECμS/cm | 1060 | 880 | 824 |
| Turbidity NUT | 1.9 | 1.2 | 0.8 |
| Bacterial Existence | 0 | 0 | 0 |

**Table 2: The analytical values of the FR samples**

| Parameters/Samples | FRO | FRI | FR2 |
|---|---|---|---|
| pH | 7.3 | 7.5 | 7.5 |
| TDS mg/L | 728 | 612 | 560 |
| Chloride mg/L | 29 | 25 | 22 |
| Phosphate mg/L | 0.08 | 0.075 | 0.082 |
| DO mg/L | 5.02 | 5.75 | 5.66 |
| EC μS/cm | 1055 | 879 | 830 |
| Turbidity NUT | 1.5 | 1.1 | 0.8 |
| Bacterial Existence | 0 | 0 | 0 |

**Table 3: The analytical values of the RT samples**

| Parameters/Samples | RTO | RT1 | RT2 |
|---|---|---|---|
| pH | 7.7 | 7.8 | 7.6 |
| TDS mg/L | 705 | 620 | 575 |
| Chloride mg/L | 18 | 17 | 17 |
| Phosphate mg/L | 0.081 | 0.08 | 0.078 |
| DO mg/L | 6.06 | 6.54 | 6.87 |
| EC μS/cm | 1014 | 896 | 822 |
| Turbidity NUT | 1.2 | 0.9 | 0.8 |
| Bacterial Existence | + | 0 | 0 |

+=TVC (95.7/10 ml), TC (820/10 ml), FC (386.7/10 ml)

**Table 4: The analytical values of the FT samples**

| Parameters/Samples | FTO | FT1 | FT2 |
|---|---|---|---|
| pH | 7.3 | 7.4 | 7.4 |
| TDS mg/L | 710 | 625 | 560 |
| Chloride mg/L | 33 | 29 | 27 |
| Phosphate mg/L | 0.081 | 0.089 | 0.08 |
| DO mg/L | 5.68 | 6.99 | 6.78 |
| EC µS/cm | 1080 | 890 | 811 |
| Turbidity NUT | 1.9 | 1.6 | 0.8 |
| Bacterial Existence | 0 | 0 | 0 |

## CONCLUSION:

Four water samples were subjected to characterization and purification experiments. Two samples from Euphrates River and another two samples from tap water. The purification experiments were conducted using a column containing a mixture of powder and granular activated carbon impregnated with potassium permanganate to enhance the adsorption performance and to give it sterilization power. The samples were analyzed for various parameters such as pH, TDS, chloride, phosphates, DO, EC, turbidity, and bacterial existence. The analytical data indicate that the samples are not suitable to be used as drinking water due to the existence of impurities. The treatment with activated carbon has a little effect on enhancing water properties.

## ACKNOWLEDGEMENTS:

Authors acknowledge Department of Chemistry, College of Science and Center of Desert Studies, University Of Anbar for their support in conducting some analysis parameters.

## CONFLICT OF INTEREST:

The authors do not have any conflict of interest.

## REFERNCES:

1. Verma KC and Kushwaha AS. Demineralization of drinking water: Is it prudent?. Medical Journal Armed Forces India. 2014; 70:377-379.
2. World Health Organization (WHO). International Standards for Drinking-Water, WHO Press, Switzerland. 1971.
3. Dwivedi AK. Researches in water pollution: A review. International Research Journal of Natural and Applied Sciences. 2017; 4(1):118-142.
4. Tambekar P, Morey P, Batra RJ, Weginwar RG. Quality assessment of drinking water: A case study of Chandrapur District (M.S.).Journal of Chemical and Pharmaceutical Research. 2012; 4(5):2564-2570.
5. Shekha YA, Ali LA, Toma JJ. Assessment of water quality and trophic status of Duhok Lake Dam. Baghdad Science Journal. 2017; 14(2):335-342.
6. Al-Fanharawi AA. A study of some physical, chemical and biological properties of Slabiaat River waters in Al-Muthanna province, Iraq. Baghdad Science Journal. 2017; 14(2):289-298.
7. Teixeira R, Nunes LM. The impact of natural organic matter seasonal variations in drinking water quality. Desalination and Water Treatment. 2011; 36:344-353.
8. Owen DM, Amy GL, Chowdhury ZK, Paode R, McCoy G, Viscosil K. NOM characterization and treatability. Journal of the American Water Works Association. 1995; 87:46-63.
9. Delpla I, Jung AV, Baures E, Clement M, Thomas O. Impacts of climate change on surface water quality in relation to drinking water production. Environment International 2009; 35:1225-1233.
10. Bruvold WH and Ongerth HJ. Taste quality of mineralized water. Journal of the American Water Works Association 1969; 61:170-174.
11. Whipple GC. The Value of Pure Water. John Wiley and Sons, New York. 1907.
12. Baseri JR, Palanisamy PN, Sivakumar P. Use of activated carbon of *Thevetia peruviana* wood for the adsorption of acid violet dye from aqueous solutions. Asian Journal of Research in Cheistry 2012; 5(4):456-461.
13. Dhananjaneyulu BV, Kumaraswamy K. Kinetic and thermodynamic studies on adsorption of malachite green from aqueous solution using mixed adsorbents. Research Journal of Pharmacy and Technology 2016; 9(10): 1671-1676.
14. Kumar JA, Amarnath DJ, Anand KV, Venkatesan D. A Study on the comparison of acenaphthene removal by using palm shell – activated carbon and iron nano metallic oxide. Research Journal of Pharmacy and Technology 2018; 11(2): 617-620.
15. Faizal KM, Mani N, Dharmambal S, Ramalingam SJ, Nandhakumar V, Thirumurugan V Decolourisation of bismark brown dye in aqueous solution using activated carbon of *Musa paradisiaca* sheath fibre. Asian Journal of Research in Chemistry 2014; 7(12): 1053-1058.
16. Hassen JH. Effect of KOH ratio on the formation of activated carbon from pressed wood residues. International Journal of Pharmaceutical Sciences and Research. 2017; 8(11):4875-4880.
17. Hassen JH, Farhan YM, Ayfan AH. Comparative study of levocetirizine elimination by pristine and potassium permanganate modified activated charcoal. International Journal of Pharmaceutical Sciences and Research. 2018; 9(12):5155-5160.
18. Lin T, Li L, Chen W, Pan S. Effect and mechanism of preoxidation using potassium permanganate in an ultrafiltration membrane system. Desalination. 2012; 286:379-388.
19. Shi Q, Zhang J, Zhang C, Nie W, Zhang B, Zhang H. Adsorption of basic violet 14 in aqueous solutions using KMnO4-modified activated carbon. Journal of Colloid and Interface Science. 2010; 343(1):188-193.
20. Bruchet A, Duguet JP, Suffe IH. Role of oxidants and disinfectants on the removal, masking and generation of tastes and odors. Reviews in Environmental Science and Biotechnology. 2004;3:33-41.
21. Zhang Y, Wang Y, Zhou L. Influence of excess KMnO4 on the adsorption of powdered activated carbon. Chemical Engineering Journal.2013; 226:279-285.
22. Gleick P. An Introduction to global freshwater issues. Water in crisis, Oxford University Press, New York.1993;pp. 3-12.
23. Dugan R: Biochemical ecology of water pollution. Plenum Publishing Company Limited, London. 1972.
24. Yang H, Zhao M, Yang JG, Chai X, Xu Y. Experimental study on the modification of granular activated carbon by potassium permanganate to adsorb Cu2+ in the water. Advanced Materials Research. 2014; 955-959:2453-2457.
25. Islam R, Faysal S, Amin R, Juliana FM, Islam MJ, Alam J et al. Assessment of pH and total dissolved substances (TDS) in the commercially available bottled drinking water. Journal of Nursing and Health Science. 2017; 6(5):35-40.
26. Daifullah AAM, Yakout SM, Elreefy SA. Adsorption of fluoride in aqueous solutions using $KMnO_4$-modified activated carbon derived from steam pyrolysis of rice straw. Journal of Hazardous Materials. 2007; 147:633-643.
27. Thilagavathi M, Arivoli S, Vijayakumaran V. Removal of chromium (VI) from aqueous solution using a low cost activated carbon prepared from *Prosopis juliflora* by adsorption. Asian Journal of Research in Chemistry 2014; 7(6): 565-569.
28. Qadir I, Chhipa RC. Studies on the removal of acid violet 49 dye by activated carbon obtained from neem leaves (*Azadirachta indica*). Asian Journal of Research in Chemistry 2014; 7(6): 345-348.
29. Sivaraja A, Shanmugapriya V. Determination of isotherm parameters for the adsorption of Rhodamine B dye onto activated carbon prepared from *Ziziphus jujuba* seeds. Asian Journal of Research in Chemistry 2017; 7(6): 362-368.
30. Susitha TC, Ezhilpriya M. Adsorption studies on bagasse for removal of residual chlorine from its aqueous solution. Research Journal of Engineering and Technology 2013; 4(4): 213-216.
31. Thakuria MN, Talukdar AK. Removal of chromium (III) from drinking water using ash of bark of *Terminalia arjuna*. Asian Journal of Research in Chemistry 2012; 5(4): 541-546.
32. Kaur H, Amutha R, Shyam R. Influence of acid treatments of sugarcane bagasse carbon sample on the adsorption of Cu (II) and Pb (II) ions from aqueous solution. Asian Journal of Research in Chemistry 2011; 4(11): 1678-1684.
33. Department of Environmental Reports on Public Health and Medical Subjects. The Bacteriological Examination of Water Supplies, London. 1977.
34. Al-Jebouri M, Trollope D. The *Escherichia coli* content of *Mytilus edulis* from analysis of whole tissue or digestive tract. Journal of Applied Bacteriology. 1981; 51(1):135-142.