Republic of Iraq
Ministry of Higher Education
And Scientific Research
Baghdad University
College of Science

Examining The Effects Of Baghdad Medical City Waste Water On The Quality Of Tigris River

A Thesis
Submitted to the College of Science /University of Baghdad In partial fulfillment of the requirements for the Master Degree of Science in Biology/Ecology

By

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Acknowledgement

Thanks for Al-mighty God for his generosity and mercy.
It is a pleasure to thank the many people who made this thesis possible.

I feel deeply indebted to my supervisor Dr. Muhammad N. Al-Azzawi for his Guidant support and kindness. Besides my advisor, I would like to thank Dr. Sedik Al-Hiyaly, Dr. Ithar Al-Mayely, Dr. Ahmed Jasim and Dr. Nazar Auda.

Special thanks to (Hussam Harby, Nefean Medhat, Muhammad Aead and Amor Hamza) in Private Nursing Home Hospital - Bacteriology lab.

I would like to express my deep feelings to my dear colleagues in Lab. And special thanks to all friends who helped and assisted me.

Lastly, and most importantly, I wish to thank my dearest family who encouraged and assisted me in every step of my life, I will indebted to my dear parents and brothers.
I introduce my work with respect.

Warqa’a Ma’alah

To whom gave me their endless love,

To whom gave me their patience and support,

To ho lighten my way to achieve this work,

I introduce my work with respect.

@ Warqa’a Ma’alah
Summary

Physical, chemical and biological characteristics of Tigris river water were assessed monthly to assess the impact of pollutants of Baghdad Medical City hospital wastewater for the period from October 2012 to September 2013. The Baghdad Medical City complex located on Baghdad on the east side of the Tigris river (Rusafa) extends between Sarafiya bridge and Bab Al-Muadham bridge. Four stations were selected during this study; the first station located 500 meters beyond the Medical City Complex, as control. The second station represents Medical City discharge into the river. The third station placed 500 meters after the second station, and the forth station is located 2000 meters after the second station. While Al-Wathba water intake that is located 70 meters before station-2 has been considered the fifth station to ensure the pollution source.

Samples collected on monthly basis from the four stations and seasonally from the fifth station, at depth of approximately 10-20 cm of water surface, two repeating samples for months. The results obtained showed that the values of Electrical Conductivity, Salinity, Turbidity, Biological Oxygen Demand, Chemical Oxygen Demand, Chlorides, Total Hardness, Calcium and Magnesium ions, Total Dissolved Solid, Total Suspended Solid, Nitrate, Heavy Metals (Fe, Cd, Pb, Ni and Zn), Total Bacterial Count, Total Coliform, Fecal Coliform, Total Streptococcus, and Fecal Streptococcus in the station 2 were found to be higher than those of other stations in mostly months during the study period. The pH and Oxygen Demand appeared lower in station 2 than those of other stations.

The results showed that Air and Water temperature values ranged between (12-33 and 11-32)°C respectively, the Turbidity values (7.4 - 250) NTU, Electrical Conductivity (537 - 1690)μs/cm, Salinity (0.32 - 1.05)‰.
The Total Dissolved Solid (339 - 1081) mg/l, Total Suspended Solid (320 - 2008) mg/l.

It was found that Tigris river water is alkaline with pH ranging from 6.02 to 9.1 with a reasonable ventilation as the oxygen values recorded varied monthly (0.3 - 11.5) mg/l. The Biological Oxygen Demand values were found to be higher at some stations (0 - 6.5) mg/l, while Chemical Oxygen Demand was (31 - 710) mg/l. The Total Hardness was very high and ranged between (170 - 625) mg/l, the Calcium (65 - 260) mg/l and Magnesium (10.9 - 104) mg/l. The Chlorides values ranged between (35 - 190) mg/l, but Nitrate values was (0.5 - 70) mg/l. These maximum results mostly exceed the permissible limit for Iraqi and WHO standards for river system maintain.

The study results showed that the concentrations of Heavy Metals (Iron, Cadmium, Lead, Nickel and Zinc) were varied between 0.9 - 0.014 mg/l, 0.1 - 0.001 mg/l, 0.6 - 0.01 mg/l, 0.4 - 0.004 mg/l, and 0.22 - 0.004 mg/l respectively. Mean concentrations of these metals in Tigris river showed monthly variations during the study period and the Fe, Ni and Zn within permissible limit, while Pb and Cd exceeding permissible limit for Iraqi and WHO standards for river system maintain.

The biological factors were recorded the values of the Total bacterial count (10000 - 2700000) cell/1ml. While Total and Faecal coliform (200-3700 and 100-2400) cell/100ml respectively. Total and Faecal Streptococcus (200-2800 and 0-920) cell/100ml respectively. The means values of this study were allowable but not desirable, while the maximum is not allowable.

The result of Al-Wathba water intake station when compared with the first station (the control), there was a significant differences with
Turbidity, Total Dissolved Solid, Total Hardness, Magnesium, Chemical Oxygen Demand, and Bacteriological tests except Faecal Streptococcus.
### List of contents

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chapter one: Introduction and literature review</td>
<td></td>
</tr>
<tr>
<td>1-1</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1-2</td>
<td>Literature review</td>
<td>4</td>
</tr>
<tr>
<td>1-2-1</td>
<td>Water pollution</td>
<td>4</td>
</tr>
<tr>
<td>1-2-2</td>
<td>Types of pollution sources</td>
<td>4</td>
</tr>
<tr>
<td>1-2-3</td>
<td>Tigris River as a source of drinking water</td>
<td>5</td>
</tr>
<tr>
<td>1-2-4</td>
<td>Water and bacteria group</td>
<td>6</td>
</tr>
<tr>
<td>1-2-5</td>
<td>Microorganism and water borne diseases</td>
<td>7</td>
</tr>
<tr>
<td>1-2-6</td>
<td>Factors that helps the spread of water borne diseases</td>
<td>10</td>
</tr>
<tr>
<td>1-2-7</td>
<td>Environmental problems with hospital wastes water</td>
<td>10</td>
</tr>
<tr>
<td>1-2-8</td>
<td>Characteristic and type of medical wastes</td>
<td>11</td>
</tr>
<tr>
<td>1-2-8-1</td>
<td>Solid Wastes</td>
<td>11</td>
</tr>
<tr>
<td>1-2-8-2</td>
<td>Liquid Wastes</td>
<td>13</td>
</tr>
<tr>
<td>1-3-8-3</td>
<td>Gaseous wastes</td>
<td>14</td>
</tr>
<tr>
<td>1-2-9</td>
<td>Water quality</td>
<td>15</td>
</tr>
<tr>
<td>1-2-9-1-1</td>
<td>physicochemical properties</td>
<td>15</td>
</tr>
<tr>
<td>1-2-9-1-2</td>
<td>Temperature</td>
<td>15</td>
</tr>
<tr>
<td>1-2-9-1-2</td>
<td>Hydrogen Ion (pH)</td>
<td>15</td>
</tr>
<tr>
<td>1-2-9-1-3</td>
<td>Electrical Conductivity (EC)</td>
<td>16</td>
</tr>
<tr>
<td>1-2-9-1-4</td>
<td>Turbidity</td>
<td>16</td>
</tr>
<tr>
<td>1-2-9-1-5</td>
<td>Salinity</td>
<td>17</td>
</tr>
<tr>
<td>1-2-9-1-6</td>
<td>Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD)</td>
<td>17</td>
</tr>
<tr>
<td>1-2-9-1-7</td>
<td>Chloride ion (Cl(^{-1}))</td>
<td>18</td>
</tr>
<tr>
<td>1-2-9-1-8</td>
<td>Total Hardness</td>
<td>18</td>
</tr>
<tr>
<td>1-2-9-1-9</td>
<td>Calcium ion (Ca(^{+2}))</td>
<td>19</td>
</tr>
<tr>
<td>1-2-9-1-10</td>
<td>Magnesium ion (Mg(^{+2}))</td>
<td>19</td>
</tr>
<tr>
<td>1-2-9-1-11</td>
<td>Total Dissolved Solids (TDS)</td>
<td>20</td>
</tr>
<tr>
<td>1-2-9-1-12</td>
<td>Total Suspended Solids (TSS)</td>
<td>20</td>
</tr>
<tr>
<td>1-2-9-1-13</td>
<td>Nitrate ion (NO(_3)^{-})</td>
<td>20</td>
</tr>
<tr>
<td>1-2-9-1-14</td>
<td>Chemical Oxygen Demand (COD)</td>
<td>21</td>
</tr>
<tr>
<td>1-2-9-2</td>
<td>Heavy Metals (HMs)</td>
<td>22</td>
</tr>
<tr>
<td>1-2-9-2-1</td>
<td>Environmental Pollution with heavy metal</td>
<td>23</td>
</tr>
<tr>
<td>1-2-9-2-2</td>
<td>Heavy metals toxicity symptoms</td>
<td>23</td>
</tr>
<tr>
<td>1-2-9-2-3</td>
<td>Iron</td>
<td>24</td>
</tr>
<tr>
<td>No.</td>
<td>Title</td>
<td>Page No.</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1-2-9-2-4</td>
<td>Cadmium</td>
<td>25</td>
</tr>
<tr>
<td>1-2-9-2-5</td>
<td>Lead</td>
<td>26</td>
</tr>
<tr>
<td>1-2-9-2-6</td>
<td>Nickel</td>
<td>26</td>
</tr>
<tr>
<td>1-2-9-2-7</td>
<td>Zinc</td>
<td>26</td>
</tr>
<tr>
<td>1-2-9-3</td>
<td>Microbial properties of water</td>
<td>27</td>
</tr>
<tr>
<td>1-2-9-3-1</td>
<td>Total Bacterial Count (T.B.C)</td>
<td>27</td>
</tr>
<tr>
<td>1-2-9-3-2</td>
<td>Total Coliform (TC)</td>
<td>28</td>
</tr>
<tr>
<td>1-2-9-3-3</td>
<td>Fecal Coliform (FC)</td>
<td>28</td>
</tr>
<tr>
<td>1-2-9-3-4</td>
<td>Total and Faecal Streptococci (TS &amp; FS)</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>Chapter two: Materials and method</td>
<td></td>
</tr>
<tr>
<td>2-1</td>
<td>The Study Area</td>
<td>30</td>
</tr>
<tr>
<td>2-2</td>
<td>Materials</td>
<td>31</td>
</tr>
<tr>
<td>2-2-1</td>
<td>Apparatuses and Equipments</td>
<td>31</td>
</tr>
<tr>
<td>2-2-2</td>
<td>Chemical compounds</td>
<td>32</td>
</tr>
<tr>
<td>2-2-3</td>
<td>Culture Media</td>
<td>33</td>
</tr>
<tr>
<td>2-2-3-1</td>
<td>Ready culture media</td>
<td>33</td>
</tr>
<tr>
<td>2-2-3-2</td>
<td>Prepared culture media</td>
<td>33</td>
</tr>
<tr>
<td>2-2-4</td>
<td>Stains, reagents and solutions</td>
<td>33</td>
</tr>
<tr>
<td>2-3</td>
<td>Sample collection</td>
<td>33</td>
</tr>
<tr>
<td>2-4</td>
<td>Methods</td>
<td>34</td>
</tr>
<tr>
<td>2-4-1</td>
<td>Sterilization</td>
<td>34</td>
</tr>
<tr>
<td>2-4-2</td>
<td>Physico-chemical measurements</td>
<td>34</td>
</tr>
<tr>
<td>2-4-2-1</td>
<td>Temperature</td>
<td>34</td>
</tr>
<tr>
<td>2-4-2-2</td>
<td>Hydrogen Ion (pH)</td>
<td>34</td>
</tr>
<tr>
<td>2-4-2-3</td>
<td>Electrical conductivity (EC)</td>
<td>34</td>
</tr>
<tr>
<td>2-4-2-4</td>
<td>Turbidity</td>
<td>35</td>
</tr>
<tr>
<td>2-4-2-5</td>
<td>Salinity</td>
<td>35</td>
</tr>
<tr>
<td>2-4-2-6</td>
<td>Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD)₂</td>
<td>35</td>
</tr>
<tr>
<td>2-4-2-7</td>
<td>Chloride ion (Cl⁻)</td>
<td>36</td>
</tr>
<tr>
<td>2-4-2-8</td>
<td>Total Hardness , Calcium and Magnesium ion</td>
<td>36</td>
</tr>
<tr>
<td>2-4-2-9</td>
<td>Total Suspended Solids ( TSS ) and Total Dissolved Solids ( TDS )</td>
<td>37</td>
</tr>
<tr>
<td>2-4-2-10</td>
<td>Nitrate (NO₃⁻)</td>
<td>38</td>
</tr>
<tr>
<td>2-4-2-11</td>
<td>Chemical Oxygen Demand (COD)</td>
<td>38</td>
</tr>
<tr>
<td>2-4-3</td>
<td>Heavy Metals test</td>
<td>39</td>
</tr>
<tr>
<td>2-4-4</td>
<td>Microbial tests</td>
<td>39</td>
</tr>
<tr>
<td>2-4-4-1</td>
<td>Total Bacterial Count (T.B.C)</td>
<td>39</td>
</tr>
<tr>
<td>No.</td>
<td>Title</td>
<td>Page No.</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>2-4-4-2</td>
<td>Total Coliform (TC) &amp; Faecal Coliform Count (FC)</td>
<td>40</td>
</tr>
<tr>
<td>2-4-4-3</td>
<td>Streptococci &amp; Faecal Streptococci (FS)</td>
<td>40</td>
</tr>
<tr>
<td>2-4-4-4</td>
<td>FC: FS Ratio</td>
<td>41</td>
</tr>
<tr>
<td>2-4-4-5</td>
<td>Diagnosis</td>
<td>41</td>
</tr>
<tr>
<td>2-4-4-6</td>
<td>Statistical Analysis</td>
<td>41</td>
</tr>
<tr>
<td>3-1</td>
<td><strong>Chapter three: Result and discussion</strong></td>
<td></td>
</tr>
<tr>
<td>3-1-1</td>
<td>Air and Water Temperature</td>
<td>42</td>
</tr>
<tr>
<td>3-1-2</td>
<td>Hydrogen Ion (pH)</td>
<td>45</td>
</tr>
<tr>
<td>3-1-3</td>
<td>Electrical Conductivity (EC) and Salinity</td>
<td>47</td>
</tr>
<tr>
<td>3-1-4</td>
<td>Turbidity</td>
<td>49</td>
</tr>
<tr>
<td>3-1-5</td>
<td>Dissolved Oxygen (DO)</td>
<td>50</td>
</tr>
<tr>
<td>3-1-6</td>
<td>Biological Oxygen Demand (BOD)</td>
<td>52</td>
</tr>
<tr>
<td>3-1-7</td>
<td>Chloride ion (Cl&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>53</td>
</tr>
<tr>
<td>3-1-8</td>
<td>Total Hardness (T.H.)</td>
<td>54</td>
</tr>
<tr>
<td>3-1-9</td>
<td>Calcium and Magnesium ion</td>
<td>56</td>
</tr>
<tr>
<td>3-1-10</td>
<td>Total Dissolved Solids (TDS)</td>
<td>58</td>
</tr>
<tr>
<td>3-1-11</td>
<td>Total Suspended Solids (TSS)</td>
<td>59</td>
</tr>
<tr>
<td>3-1-12</td>
<td>Nitrate (NO&lt;sub&gt;3&lt;/sub&gt;&lt;sup&gt;-2&lt;/sup&gt;)</td>
<td>60</td>
</tr>
<tr>
<td>3-1-13</td>
<td>Chemical Oxygen Demand (COD)</td>
<td>61</td>
</tr>
<tr>
<td>3-2</td>
<td><strong>Heavy Metals (HMs)</strong></td>
<td></td>
</tr>
<tr>
<td>3-2-1</td>
<td>Iron (Fe)</td>
<td>62</td>
</tr>
<tr>
<td>3-2-2</td>
<td>Cadmium (Cd)</td>
<td>64</td>
</tr>
<tr>
<td>3-2-3</td>
<td>Lead (Pb)</td>
<td>65</td>
</tr>
<tr>
<td>3-2-4</td>
<td>Nickel (Ni)</td>
<td>66</td>
</tr>
<tr>
<td>3-2-5</td>
<td>Zinc (Zn)</td>
<td>67</td>
</tr>
<tr>
<td>3-3</td>
<td><strong>Microbial properties</strong></td>
<td></td>
</tr>
<tr>
<td>3-3-1</td>
<td>Total Bacterial Count (T.B.C)</td>
<td>68</td>
</tr>
<tr>
<td>3-3-2</td>
<td>Total Coliform (TC)</td>
<td>69</td>
</tr>
<tr>
<td>3-3-3</td>
<td>Faecal Coliform (FC)</td>
<td>71</td>
</tr>
<tr>
<td>3-3-4</td>
<td>Total Streptococci (TS)</td>
<td>72</td>
</tr>
<tr>
<td>3-3-5</td>
<td>Faecal Streptococci (FS)</td>
<td>73</td>
</tr>
<tr>
<td>3-3-6</td>
<td>FC: FS Ratio</td>
<td>74</td>
</tr>
<tr>
<td>3-3-7</td>
<td>Diagnosis</td>
<td>75</td>
</tr>
<tr>
<td>3-4</td>
<td>The fifth station (Al-Wathba water intake)</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td><strong>Conclusions and Recommendations</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>77</td>
</tr>
</tbody>
</table>

References
List of tables

<table>
<thead>
<tr>
<th>Table no.</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>The bacteria transmitted through drinking water and sources of transmission</td>
<td>9</td>
</tr>
<tr>
<td>1-2</td>
<td>The types and colours of the bags or containers used to collect waste</td>
<td>12</td>
</tr>
<tr>
<td>1-3</td>
<td>The international marks of the waste</td>
<td>13</td>
</tr>
<tr>
<td>1-4</td>
<td>Iraqi, WHO and American Standard s for River Water Quality</td>
<td>21</td>
</tr>
<tr>
<td>1-5</td>
<td>Iraqi, WHO and American Standards for River Water Quality</td>
<td>27</td>
</tr>
<tr>
<td>1-6</td>
<td>Bacteriological characteristics of the surface water</td>
<td>29</td>
</tr>
<tr>
<td>2-1</td>
<td>Apparatuses and Equipments used in this study</td>
<td>31</td>
</tr>
<tr>
<td>2-2</td>
<td>Chemicals used in the study</td>
<td>32</td>
</tr>
<tr>
<td>2-3</td>
<td>Ready culture Media used in the study</td>
<td>33</td>
</tr>
<tr>
<td>3-1</td>
<td>Minimum and maximum (First Line), mean and standard deviation (Second Line), for physical and chemical characteristics in studied stations during 2012-2013.</td>
<td>44</td>
</tr>
<tr>
<td>3-2</td>
<td>The correlation among water parameters.</td>
<td>45</td>
</tr>
<tr>
<td>3-3</td>
<td>Minimum and maximum (First Line), mean and standard deviation (Second Line), for heavy metals studied (Fe, Cd, Pb, Ni and Zn) at studied stations during 2012-2013.</td>
<td>63</td>
</tr>
<tr>
<td>3-4</td>
<td>The correlation among some water parameters and heavy metals</td>
<td>64</td>
</tr>
<tr>
<td>3-5</td>
<td>Minimum and maximum (First Line), mean and standard deviation (Second Line), for bacteriological characteristics at studied stations during 2012-2013</td>
<td>69</td>
</tr>
<tr>
<td>3-6</td>
<td>FC: FS Ratio</td>
<td>74</td>
</tr>
<tr>
<td>3-7</td>
<td>Bacteria genera and species isolated from four stations selected by API System</td>
<td>75</td>
</tr>
<tr>
<td>Fig. No.</td>
<td>Title</td>
<td>page</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>2-1</td>
<td>Sampling stations on Tigris River: Map from (Google Earth Pro).</td>
<td>31</td>
</tr>
<tr>
<td>3-1</td>
<td>Monthly variation in Air Temperature (°C) during 2012/2013</td>
<td>43</td>
</tr>
<tr>
<td>3-2</td>
<td>Monthly variation in water Temperature (°C) in Tigris river during 2012/2013</td>
<td>43</td>
</tr>
<tr>
<td>3-3</td>
<td>Monthly variation in Hydrogen Ion in Tigris river during 2012/2012</td>
<td>47</td>
</tr>
<tr>
<td>3-4</td>
<td>Monthly variation in Electrical conductivity in Tigris river during 2012/2013</td>
<td>48</td>
</tr>
<tr>
<td>3-5</td>
<td>Monthly variation in Salinity in Tigris river during 2012/2013</td>
<td>49</td>
</tr>
<tr>
<td>3-6</td>
<td>Monthly variation in Turbidity in Tigris river during 2012/2013</td>
<td>50</td>
</tr>
<tr>
<td>3-7</td>
<td>Monthly variation in Dissolved Oxygen in Tigris river during 2012/2013</td>
<td>51</td>
</tr>
<tr>
<td>3-8</td>
<td>Monthly variation in Biological Oxygen Demand in Tigris river during 2012/2013</td>
<td>53</td>
</tr>
<tr>
<td>3-9</td>
<td>Monthly variation in Chloride Ion in Tigris river during 2012/2013</td>
<td>54</td>
</tr>
<tr>
<td>3-10</td>
<td>Monthly variation in Total Hardness in Tigris river during 2012/2013</td>
<td>55</td>
</tr>
<tr>
<td>3-11</td>
<td>Monthly variation in Calcium Ion in Tigris river during 2012/2013</td>
<td>57</td>
</tr>
<tr>
<td>3-12</td>
<td>Monthly variation in Magnesium Ion in Tigris river during 2012/2013</td>
<td>58</td>
</tr>
<tr>
<td>3-13</td>
<td>Monthly variation in Total Dissolved Solids Ion in Tigris river during 2012/2013</td>
<td>59</td>
</tr>
<tr>
<td>3-14</td>
<td>Monthly variation in Total Suspension Solids in Tigris river during 2012/2013</td>
<td>60</td>
</tr>
<tr>
<td>3-15</td>
<td>Monthly variation in Nitrate in Tigris river during 2012/2013</td>
<td>61</td>
</tr>
<tr>
<td>3-16</td>
<td>Monthly variation in Chemical Oxygen Demand in Tigris river during 2012/2013</td>
<td>62</td>
</tr>
<tr>
<td>3-17</td>
<td>Iron in Tigris river monthly variation during 2012/2013</td>
<td>63</td>
</tr>
<tr>
<td>3-18</td>
<td>Cadmium in Tigris river monthly variation during 2012/2013</td>
<td>65</td>
</tr>
<tr>
<td>3-19</td>
<td>Lead in Tigris river monthly variation during 2012/2013</td>
<td>66</td>
</tr>
<tr>
<td>3-20</td>
<td>Nickel in Tigris river monthly variation during 2012/2013</td>
<td>67</td>
</tr>
<tr>
<td>3-21</td>
<td>Zinc in Tigris river monthly variation during 2012/2013</td>
<td>68</td>
</tr>
<tr>
<td>3-22</td>
<td>Total Bacterial Count (T.B.C) monthly variation in Tigris river during 2012/2013</td>
<td>69</td>
</tr>
<tr>
<td>Fig. No.</td>
<td>Title</td>
<td>page</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>3-23</td>
<td>Total Coliform monthly variation in Tigris river during 2012/2013</td>
<td>71</td>
</tr>
<tr>
<td>3-24</td>
<td>Faecal Coliform monthly variation in Tigris river during 2012/2013</td>
<td>72</td>
</tr>
<tr>
<td>3-25</td>
<td>Total Streptococci monthly variation in Tigris river during 2012/2013</td>
<td>73</td>
</tr>
<tr>
<td>3-26</td>
<td>Faecal Streptococci monthly variation in Tigris river during 2012/2013</td>
<td>74</td>
</tr>
</tbody>
</table>

**List of appendix**

<table>
<thead>
<tr>
<th>Appendix .no</th>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medical City Hospitals survey</td>
<td>96</td>
</tr>
<tr>
<td>2</td>
<td>Fig. a, b and c represent station-2</td>
<td>97</td>
</tr>
<tr>
<td>3</td>
<td>Fig. represent Al-Wathba water intake (The fifth station)</td>
<td>98</td>
</tr>
<tr>
<td>4</td>
<td>API 20E System</td>
<td>98</td>
</tr>
<tr>
<td>5</td>
<td>API Staph System</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Bacillus Diagnosis</td>
<td>102</td>
</tr>
</tbody>
</table>

**List of abbreviates**

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>Chemical Oxygen demand</td>
</tr>
<tr>
<td>EC</td>
<td>Electrical Conductivity</td>
</tr>
<tr>
<td>EDTA</td>
<td>Ethylene Diamin Tetra Acetic acid</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FC</td>
<td>Fecal Coliform</td>
</tr>
<tr>
<td>FS</td>
<td>Fecal Streptococci</td>
</tr>
<tr>
<td>HMS</td>
<td>Heavy Metals</td>
</tr>
<tr>
<td>MPN</td>
<td>Most Probable Number</td>
</tr>
<tr>
<td>NTU</td>
<td>Nephelometric Turbidity Unit</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>TC</td>
<td>Total Coliform</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>TH</td>
<td>Total Hardness</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children's Fund</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>APHA</td>
<td>American Public Health Association</td>
</tr>
<tr>
<td>FAAS</td>
<td>Flame Atomic Absorption Spectrometry</td>
</tr>
</tbody>
</table>
1-1 Introduction

Water is a vital resource to sustain life, and a satisfactory must be of adequate, safe and accessible, and available to all population (WHO, 2006-c). However water is the important constituent of life in all natural ecosystems. Water has wide different spectrum of domestic, industrial, agricultural, medical, and other human applications, which in turn would result in water contamination (Pandey, 2006).

Approximately, 20% of the world’s population lacks safe drinking water and nearly half the world population lacks adequate sanitation, this problem is acute in many developing countries, which discharge an estimated 95% of their untreated urban sewage directly into surface waters, Iraq which is one of the nine Middle Eastern countries has insufficient fresh water (Pimental et al., 2004).

Water pollution is the contamination of water by natural and foreign matter such as micro-organisms, chemicals, industrial or other wastes, or sewage in quantities likely to cause harm to living organisms (Wright, 2004).

The U.S. Environmental Protection Agency (EPA) defines pollution as the presence of substances in the environment which is due to their chemical composition or quantity, prevent or hinder the natural processes, and cause undesirable environmental and health effects, and that any substance that causes pollution called pollutant, (Wright & Nebel, 2002).

Wastewater generated from hospitals usually contains pathogens, human wastes and fluids, pharmaceuticals, substances with genotoxic properties, chemical substances, heavy metals, and radio-active wastes. This may endanger public health and welfare, contribute to oxygen demand and nutrient loading of the water bodies and in the process promote toxic algal blooms and leading to a destabilized aquatic ecosystem, if discharged without treatments into water bodies (Ojo, et al., 2012).

In developing countries, the average demand for water by hospitals is 500 L/bed/day. In addition to this high demand for drinking water, the requirement for specific waters such as physiological solution, sterilised water and serums. This consumption of water by hospitals, which far exceeds the minimum household consumption of 100 L per inhabitant per day, gives rise to large volumes of wastewater. Indeed, the chemical substances used in hospitals for healthcare and medical research are
frequently found in liquid effluents (Emmanuel et al., 2009) that are discharged in the same way as classical urban effluents into the communal drainage network without prior treatment (Emmanuel et al., 2005).

Physicochemical and microbiological characterisation studies performed on hospital effluents in several industrialised countries, have reported the presence of pathogenic microorganisms, some of which are multi-resistant to antibiotics (Leprat, 1998), heavy metals (Emmanuel et al., 2005), radioisotopes (Erlandsson & Matsson, 1978), organohalogenes, stemming in particular from the use of bleach on organic compounds present in effluents (Emmanuel et al., 2004), and drug residues (Kümmerer, 2001). Some of these pollutants, especially drug residues and organohalogenes, are frequently discharged through sewage plants after having undergone little degradation (Emmanuel et al., 2009). Hospital wastewaters are complex mixtures (Boillot & Perrodin, 2008), capable of generating major environmental problems, as they are 5 to 15 times more toxic than classical urban effluents (Panouillères et al., 2007).

Hospital wastewater reveals the presence of molecules chlorinated at high concentrations and in a punctual way the presence of heavy metals such as mercury and silver. The application of Ames and Hamster cell tests on hospital wastewater indicated that these effluents are potentially mutagenic. The origin of this mutagenic potential remains to be investigated. The value of the total hospital wastewater showed a high toxicity as determined using the daphnia and luminescent bacteria tests (Emmanuel et al., 2002).

So the aims of this study are as follows:

1. Water chemical, physical and biological evaluation of Tigris river.
2. Investigate the effect of medical waste water from Baghdad Medical City and possible effects on Tigris river.
1-2 Literature reviews:

1-2-1 Water pollution:

Water pollution may define as anything that degrades water quality and adversely affects living organisms or makes water unsuitable for usage (Cunningham et al., 2007). Thurman and Webber (1984) defined water pollution as an addition of materials or energy by man to the aquatic environment to be sufficient to cause harm to human health or living resources and ecosystems, or the overlap between the legitimated uses of the environment. Holdgate (1979) defined and described pollution as an addition of materials or energy by man or the various non-studied human activities to the aquatic environment which can be able to create damage to human and organism’s health in addition to the different ecosystems.

1-2-2 Types of pollution sources:

1-2-2-1 Point pollution:

It is contamination that could be traced to a particular source such as an industrial site, septic tank, or wastewater treatment plant (Bitton, 2005).

1-2-2-2 Nonpoint pollution:

This type of water pollution results from large areas and not from any single source which includes both natural and human activities. Sources of nonpoint pollution include agricultural, human, forestry, urban, construction, mining activities and atmospheric deposition. There are also naturally occurring nonpoint source pollutants that are important. These however include geologic erosion, saline seeps; breakdown of minerals and soils that may contain large quantities of nutrients and heavy metals at varies levels (Bitton, 2005).
Tigris River as a source of drinking water:

Tigris is the biggest river in Iraq and the main source of drinking water for Baghdad, which is the largest city in the country and the second largest city in the Arab world with a population estimated by 7.5 million (Razzak et al., 2009). Nevertheless there are no enough reliable studies, data or statistics available internationally about Tigris River (Kavvas et al., 2011) and its water quality while traversing Iraq, especially after the year 2003 is deteriorated. Any pollution of Tigris river may cause a direct pollution to Euphrates river and the related water sources since both rivers connected through Al-Tharthar lake (Rahi & Halihan, 2010). Water quality studies have focused on cases where sever pollution problems are arises, especially in heavily populated urban areas. Baghdad city is over populated and produced a huge amount of wastewater from different sources which are disposed into Tigris river directly or after treatment. In the last few years, an increase of wastewater directly disposed in the river using pump stations of storm sewer network have caused high pollution levels in the river's water (Razzak et al., 2009).

According to UNICEF report, about 800 million people in Asia and Africa are living without access to safe drinking water. Consequently this has caused many people to suffer from various diseases. Contamination of water has been frequently found associated with transmission of diseases causing bacteria, Vibrio, Salmonella, bacterial and parasitic dysentery, and acute infection diarrhea causing E.coli (Al-Bayatti et al., 2012). Poor sanitation and food sources are integral to enteric pathogen exposure. Drinking water is a major source of microbial pathogen and considered to be one of the main reasons for increased mortality rates among children in developing countries (Kondakal et al., 2009). Comprehensive evaluations of microbial quality of water require survey of all the pathogens that have potential for human infections (Miranzadeh et al., 2011).

Water Quality Index was analysed by Al-Obaidy et al. (2010) to evaluate the raw and treated drinking water from Tigris river within Baghdad. Using this approach Al-Obaidy and his colleagues showed that Tigris water never reached “Excellent” level nor fallen to “unsuitable” condition, except in occasional untreated water sample. It is thus important to study and know the physical, chemical, and biological nature of this water to ascertain hygienic quality of water sources for human consumption and for general community purposes. Al-Fatlawy (2007) studied the quality of drinking water for some Baghdad water liquefaction projects, including
Al - Karama station from the main source for the processing of the raw water it is the Tigris River, and conducted chemical, physical and biological tests of river water at the outlet water projects. Results showed high values of the total numbers of bacteria in the winter and low concentrations in the summer. Low rates of Coliform, Fecal Coliform and \textit{E.coli} in the summer and the height of the spring water. Where the areas of Al - Karama project, namely: Al-Utaifiyya, Al-Kadhimiya, and Al-Horai is the best in the percentages of chlorine, turbidity and bacteriological examination.

WHO drinking water quality guidelines and Iraqi standards both recommended that Feacal Coliform must not exist in 100 ml of portable water sample (WHO, 2004).

1-2-4 Water and bacteria groups:

The bacteria are the most important groups of microorganisms that are prevalent in the aquatic environment, and water normally contains bacterial flora. In addition to Autochthonous aquatic bacteria, there is Allochthonous aquatic bacteria, which invade the aquatic environment from various source such as flash floods of the soil and rain and the remnants of animal, plant tissue that may find their way to the water (Al- Sammarai, 2009).

References refers that most water bacteria are Gram-negative, non-spore-forming, bacilli form. While the others are Gram-positive, most water bacteria is not self-nutrition play an important role in the analysis of organic compounds in water and thus contribute effectively to rotate the elements in the aquatic environment (Al-Moslah, 1988).

Preston \textit{et al.}, (1980) referred that break down organic materials is one of the important operations carried out by microorganism contaminated water, which lead to the production of gases such as methane, carbon dioxide and hydrogen sulphide, which affect the chemical content of the aquatic environment.

Entry and Farmer (2000) mentioned that coliform and fecal coliform are the most suitable evidence to study the pollution of natural water with infected bacteria because their presence means the presence of bacteria or micro-organisms a satisfactory to humans.
1-2-5 Microorganism and water borne diseases:

Water is the most available means for the spread of diseases in the environment depending on the capacity of the spread, direct and continuous contact of objects as a prerequisite for the continuation of life (WHO, 2000). Where the mortality rate resulting from the consumption of contaminated water between (2-12) million deaths annually, and inefficiency of the process of treatment and disinfection of water and the lack of attention in the maintenance of distribution systems is the main reason for the outbreak of diseases in water (Gebra and Rose, 2003).

The WHO (2010) indicated that most of the water borne diseases generally infects the gastrointestinal tract and excreted in the feces of infected humans and animals. It is considered Faecal contaminants of the most prevalent and dangerous contaminants in water. There are a lot of bacteria that have the ability to penetrate the distribution systems, grow and reproduction inside it, but a few of them cause diseases to humans. Water is the main source of disease infection because it is a carrier media for many of the microorganisms that have negative effect on life in various fields, as many of the world's population still depend on surface waters of rivers, streams or even lakes as sources of water drinking them.

Taylor (1958) pointed that the cause of the deaths with cholera epidemic was due to using drinking water from a wells contaminated with human waste, and also pointed to the exposure of 18,000 people in the city of Hamburg to cholera infection by drinking water unliquidated river Alba and that led to more than 800 deaths. On the other hand WHO (1976) reports refer to 80% of the diseases in the world are causing the use of contaminated water, nearly half a million people in the world suffer from the problems of the use of contaminated water, Ten million people (the great majority of them are children) die each year because of some dangerous diseases as Typhoid, cholera, hepatitis and amoebic dysentery caused by the use of unhealthy water.
Table (1-1) shows the bacteria transmitted through drinking water and sources of transmission. (Dziuban et al., 2006).

<table>
<thead>
<tr>
<th>Disease and Transmission</th>
<th>Microbial Agent</th>
<th>Supply Sources of Agent in Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botulism</td>
<td><em>Clostridium botulinum</em></td>
<td>Bacteria can enter an open wound from contaminated water sources. Can enter the gastrointestinal tract by consuming contaminated drinking water or (more commonly) food.</td>
</tr>
<tr>
<td>Cholera</td>
<td><em>Vibrio cholerae</em></td>
<td>Water contaminated with the bacteria</td>
</tr>
<tr>
<td><em>E. coli</em> Infection</td>
<td><em>Escherichia coli</em></td>
<td>Water contaminated with the bacteria</td>
</tr>
<tr>
<td>Dysentery</td>
<td><em>Salmonella</em> and <em>Shigella</em> (the Shigella most common <em>Shigella dysenteriae</em>).</td>
<td>Water contaminated with the bacteria</td>
</tr>
<tr>
<td>(two distinct Legionellosis forms: Legionnaires' disease and Pontiac fever)</td>
<td>(90% of cases <em>Legionella</em> caused by <em>Legionella pneumophila</em>).</td>
<td>Contaminated water: the organism thrives in warm aquatic environments</td>
</tr>
<tr>
<td>Salmonellosis</td>
<td><em>sp.Salmonella</em></td>
<td>Drinking water contaminated with the bacteria. More common as a food borne illness.</td>
</tr>
<tr>
<td>Typhoid fever</td>
<td><em>Salmonella typhi</em></td>
<td>Ingestion of water contaminated with feces of an infected person</td>
</tr>
<tr>
<td>Vibrio Illness</td>
<td><em>Vibrio Vulnificus alginoalyticus</em>, and <em>Vibrio parahaemolyticus</em></td>
<td>Can enter wounds from contaminated water.</td>
</tr>
<tr>
<td>Hepatitis (type A)</td>
<td>Hepatitis A Virus (HAV)</td>
<td>Water contaminated with Hepatitis (type A)</td>
</tr>
</tbody>
</table>
1-2-6 Factors affecting the spread of water borne diseases:

According to WHO (2006) report, the factors helping the spread of water borne diseases can be summarized as follows: -

a. Temperature.
b. Water application
c. Ignore the health regulations and personal hygiene.
d. The presence of organic contamination.
e. Absent of conservation and deliberate pollution.

1-2-7 Environmental problems with hospital waste water:

One of the main environmental problems putting by the hospital effluents is their discharge, in the same way as the urban classic effluents, towards the urban sewer network without preliminary treatment (Emmanuel et al., 2002).

There is a similarity between hospitals wastewater and household wastewater, but it is characterized by containing hazardous many compounds and microorganism and include bacteria, viruses, and hazardous chemicals and materials sterilized in addition to radiation development laboratory waste, which is characterized by the presence of chemicals toxic, so the hospital put large amounts of liquid wastewater change their quantity and quality from one hour to another and from one season to another, where the discharge (300-1000 litres/person/day) hence the urgent need for waste water treatment issued by the hospital to reduce the dangers that may be caused these pollutants to civilian sources without treatment (Elia, 2010).

Al Tamer and Abdul Hady (2013) have examined certain hospitals in Mosul and the impact on the Tigris river and showed the values of COD, chlorine, sulfates and phosphates exceed the permissible limits. And the Iraqi Ministry of Environment (2009) reports show that high value of BOD, TSS, and COD of liquid waste for Baghdad, child protection and surgical hospitals in Baghdad Medical City.

1-2-8 Characteristic and type of medical waste:
Quality and quantity of waste water produced by every hospital depends on different factors. Some of these factors are: bed numbers, accessibility to water, kind of health services, number of units; climate situation, people’s culture and geographical situation which result in variety of hospital waste water production and defines that necessary treatment should be carried-out on them before their entrance into urban waste water network (Sabzali & Shivaii, 2006).

Represents the waste of the health institutions all waste generated by hospitals, health centres, clinics, laboratories, medical research centers, forensic medicine and anatomy centres (Sharef et al., 2008). It’s classified into several types according to their nature also differ in the treatment way (Prüss, 1999; Twinch, 2011):  

**1-2-8-1 Solid Wastes:**

Solid waste posed from health institutions can be divided in general into several sections are different in nature and ways to deal with it and disposal methods, it’s:

a. **Municipal wastes:**

Made as a result of administrative and clerical activities include (paper, newspapers, plastic, glass, metal cans and leftovers) waste.

b. **Radioactive wastes:**

Resulting from the treatment of patients, increases the need for medicines, and expired medicines, or the result of some appliances and equipment used for treatment or diagnosis.

c. **Chemical wastes:**

Waste containing chemical substances: e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents.

d. **Infectious medical wastes:**

May be caused by blood, bacterial, viral, parasitic and fungal labs, or be used for patients (needles, blades, medicine containers, plastic tubes or bed sheets and pillows contaminated and human parts) Which is different severity by disease, Pathological samples (for patients), which has been laboratory tested and dumped the remains in containers, their significant
impact on the spread of infection among healthy people it is essential if the full knowledge of all the risks (Infection) and destruction of pathological specimens immediately within the safety and security procedures appropriate and accurate

Table (1-2) shows the types and colours of the bags or containers used to collect waste (Iraqi Ministry of Environment, 2009).

<table>
<thead>
<tr>
<th>Waste type</th>
<th>Container Colour</th>
<th>Container Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Highly infectious waste</td>
<td>Yellow index it (highly infectious)</td>
<td>Bags (or container) leak proof plastic</td>
</tr>
<tr>
<td>2 Waste-causing infectious disease and anatomical waste</td>
<td>Yellow</td>
<td>Bags (or container) leak proof plastic</td>
</tr>
<tr>
<td>3 Sharps</td>
<td>Yellow index it (Sharp materials)</td>
<td>Non-breach container</td>
</tr>
<tr>
<td>4 Chemical and pharmaceutical waste</td>
<td>Brown</td>
<td>Plastic bag or container</td>
</tr>
<tr>
<td>5 Radioactive waste</td>
<td>-----</td>
<td>Metal box marked with radiation mark</td>
</tr>
<tr>
<td>6 Public waste of health care</td>
<td>Black</td>
<td>Plastic bag</td>
</tr>
</tbody>
</table>
Table (1-3) shows the international marks of the Waste (Iraqi Ministry of Environment, 2009).

<table>
<thead>
<tr>
<th>Infectious biological and medical waste</th>
<th>Radioactive medical waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incendiary chemical waste</td>
<td>Chemical waste</td>
</tr>
<tr>
<td>Genotoxic drugs waste</td>
<td>Chemical waste highly reactive with water</td>
</tr>
<tr>
<td>Harmful medical waste</td>
<td>Flammable waste</td>
</tr>
</tbody>
</table>

1-2-8-2 Liquid Wastes:

Liquid waste posed from health institutions can be divided in general into several sections which are different in nature and ways to deal with it and disposal methods, it’s:

a) Sewage:

Sewage hospitals contain large amounts of microbial infectious diseases (bacteria and viruses) that move easily through the water, where sewage contaminated by infectious and contagious diseases or during epidemics.
b) Hazardous chemical liquid:
Resulting from the sterilization process and the daily cleaning of the devices, equipment, surfaces and floors where there are large amounts of solvents including acids, organic and Inorganic alkaloids is discharged to public sewage from analysis and pathological laboratories without treatment.

c) Pharmaceutical wastes:
Small amounts of drugs are discharged to sewage of different medical departments and these drugs may contain antibiotics, cytotoxic drugs and some other species.

d) Radioactive liquid wastes:
Small amounts of radioactive liquid waste go to sewage from the tumors treatment departments.

e) Heavy Metal residues wastes:
Quantities of heavy metals with high toxicity are discharged, such as mercury, silver, lead from dental services centres and radiology departments, and by spillage from broken clinical equipment (thermometer, blood pressure gauge .. etc.). Cadmium waste comes mainly from discarded batteries. A number of drugs contain arsenic.

1-2-8-3 Gaseous wastes:
Gaseous waste consist of burning waste process in the central holocaust inside the complex, where it is burning all medical solid waste (syringes, blood bags damaged, nutritious plastic bags .. etc.) and these substances cause pollution if not burned under suitable temperature due to be Dioxin material, which is made up of hundreds of chemicals remain for long periods in the environment because dioxin does not react with oxygen and water and is not degraded by bacteria, it’s consists of two petrol ring linking them by two oxygen atoms.
1-2-9 Water quality:

Water quality means all physical characteristics (temperature, odour, turbidity... etc.), chemical (dissolve oxygen, salts and other chemicals) and biological (infectious agents, phytoplankton and zooplanktons) all should be at un effective levels of acceptability, quality described as unacceptable in case one or more of characters change (WHO, 1996).

1-2-9-1 physicochemical properties:

The physical and chemical properties are great important in aquatic systems through their influence in determining the quality of good water. This is done by comparing these factors with global standard specifications for water quality, considering that water plays a major role in maintaining the health and safety of the consumer (Table 1-4). These factors continuously varying depending on the nature of geological and climatic conditions of the study area (Stark et al., 2000).

1-2-9-1-1 Temperature:

Heat affects the physical and chemical characteristics of water directly and indirectly, as affecting the metabolic processes such as photosynthesis, osmosis, respiration, and organization in aquatic plants and animals as well as its impact on the density and viscosity of water and soluble gases (Al-Aney, 2012).

1-2-9-1-2 Hydrogen Ion (pH):

pH plays a major role in the survival of aquatic organisms, and affects their distribution in the water, because many proteins and enzymes affected by the high and low pH. Most aquatic organisms require a pH within range of 5 to 8.5 for optimal growth and reproduction, although they may survive for a time at pH values outside this range. The toxicity of many pollutants is pH dependent (Al-Zubaidi, 2011). Generally the favourite term of living aquatic is (6 - 8.5) (USEPA, 2002). This value is in the water be related to seasonal changes, the amount and type of organic material and density of phytoplankton (Al-Moslah, 1988).

1-2-9-1-3 Electrical Conductivity (EC):

Electrical Conductivity was used to give an idea of the amount of dissolved chemical ions in water, and presence of sodium, potassium, and chlorine. There are swayed health effects on human life through these electrolytes, like disorder of salt and water balance in infants, heart patients, individuals with high blood pressure, and renal problems. Significant
changes in electrical conductivity may indicate that water body has received certain pollutants (GWADW, 2009).

1-2-9-1-4 Turbidity:

Turbidity defined as an expression of the optical property of a medium which causes light to be scattered and absorbed rather than transmitted in straight lines through the sample and it is an important water quality variable (Lawler et al., 2006). The turbidity means water purity measurement, the increase of the levels of turbidity in the water may determine the growth of some organisms and if it significantly reduced in the water, it may increase the sensitivity to toxic substances (Al-Aney, 2012), the sources of turbidity include:

a) Soil erosion.
b) Waste discharge.
c) Urban runoff.
d) Eroding stream banks.
e) Large numbers of bottom feeders that stir up bottom sediments.
f) Excessive algal growth.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This reduces the concentration of DO because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom (especially in slower waters) and smother fish eggs and benthic macro invertebrates (Spellman, 2003).

1-2-9-1-5 Salinity:

Is a measure of dissolved salts in the water, as it is basic recipe salinity in determining the use of water for industrial and agricultural purposes. The salts have role in preventing the growth of bacteria through their work to break down protein and inhibition biological processes of bacteria and death (Humudat, 2009). The increase in salinity is coupled with an increase of sodium chloride, chlorides, sulphates, potassium and calcium (CWT, 2004).
Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD₅):

Dissolved Oxygen enters into aquatic system through direct diffusion and as a by-product of photosynthesis. DO is an indicator of water quality, low levels can produce anaerobic conditions leading to smelly water (Hashim, 2010). Dissolved Oxygen levels depend on physical, chemical and biological activities in water, the oxygen content of natural waters varied with temperature, salinity, turbulence, atmospheric pressure and the photosynthetic activity of algae and plant (Cameron et al., 2003).

The Biological Oxygen Demand is an approximate measure of the amount of biochemically degradable organic matter present in a water sample; it is defined by the amount of oxygen required for the aerobic microorganisms present in the sample to oxidize the organic matter to a stable inorganic form (Chapman, 1996). Another definition is BOD the measure of oxygen used up by biological and chemical processes in a sample water over a 5days period at 25°C (WHO, 2004).

One of the most important criteria in assessing the quality of raw water, O₂ concentration in water which depends on the water temperature and the concentration of dissolved salts. It reduces when organic contaminants increased, and in eutrophication by algae. Consumption of dissolved oxygen in water, leading to the death of living organisms, which are clustered at the bottom so the anaerobic bacteria become available, so the water becomes foul-smelling as a result of the collected gases produced by bacteria (Ben Sadiq, 2003).

Chloride ion (Cl⁻):

The chloride ion is available in all natural water at different concentrations. As it reaches its concentration in ocean water to more than 2000 mg/l. But in the rivers and lakes water, the concentration ranges between 20 – 80 mg/l. The sedimentary rocks the main source of chloride ion as well as rain water and melting snow. Another source of chloride ion in the groundwater is contaminated organic waste or industrial waste and irrigation water. Also, the water treatment with chlorine can lead to increased concentration of chloride ion in the water (Daly, 1994).
**1-2-9-1-8 Total Hardness (T.H):**

Hardness is a traditional measure of water quality and suitability for human use. The hardness caused by various metals ions (calcium, magnesium, and other metal ions polyvalent such as iron, aluminium, tin, zinc and hydrogen ion (Lower, 2007). There are two type of hardness (Al-Obaidy, 2008):
- Temporary hardness: Called Carbonate hardness due to present calcium carbonate \([\text{Ca(HCO}_3\text{)}_2]\) and magnesium carbonate\([\text{Mg(HCO}_3\text{)}_2]\), its remains mostly by heating to boiling
- Permanent hardness: Called Non-Carbonate Hardness due to present calcium and magnesium chloride and sulphate.

Some studies have found that increase hardness water lead to infect children with eczema in Japan, and the hardness lead to rust tank (Miyak et al, 2004).

**1-2-9-1-9 Calcium ion (Ca \(^{+2}\)):**

The atomic number (20) and atomic weight (40.08). Which is the main positive ion in natural waters. Calcium ion is a major source of hardness so does not favour its presence in high concentrations in drinking water. But it is one of the important elements and favourite in irrigation water because it strengthens and permeability the soil and keeps the building (Jassim, 1988).

Calcium ion is important of the organism body, it’s necessary in the stages of embryonic development, pregnancy and lactation as well as its importance in the growth of teeth, bones, blood clotting formation, and the working of nervous system (Abed & Alwakeel, 2007). Study carried by Al-Aadhamy (1996) has shown that the calcium ion concentration in the wastewater to the city of Baghdad in Rusafa was limits to 95 – 199 mg/l which is a result of domestic water use.

**1-2-9-1-10 Magnesium ion (Mg \(^{+2}\)) :**

This metals has atomic number (12) and atomic weight (24.306), Magnesium element is less abundant in water compared with calcium as up rate of between 1 to tens mg/l. It is a cofactor for some cellular enzymes, many of which were involved in energy metabolism. It was also involved in protein and nucleic acid synthesis (WHO, 2011). In a study of Al-Aadhamy (1996) has indicated that the magnesium ion concentration in the wastewater to the city of Baghdad - Rusafa ranging between 11 - 93 mg/l, and this concentration result of domestic use. Use Magnesium salts is
considered toxic if inhaled, and increase the concentration of more than 125 mg/l possible cause diarrhea (APHA, 1998).

1-2-9-1-11 **Total Dissolved Solids (TDS):**

TDS known as the sum of positive and negative ions and some rare secondary elements and do not include suspended solids, colloidal or dissolved gases in solution (Davis, 1966). As in the liquidation of the traditional drinking water may not affect the concentration of these materials because they are soluble materials may increase its concentration in the drinking water due to the addition of alum. The groundwater and water joists, water drainage and household and industrial waste have an important role to play and a great addition of large amounts of dissolved solids to the river (Al-Obaidy, 2008). And according to Killimentov (1983) classification the Tigris river water is fresh water in terms of concentration of TDS.

1-2-9-1-12 **Total Suspended Solids (TSS):**

A Total Solids remaining on the filter paper after filtration which includes clay, sand, silt, and other materials floating on the surface of the water and the high value of this material is evidence of water contamination by sewage, the effect of the suspended solids in drinking water and river water, has found to reduces the degree of palatability of drinking water and reduce the effectiveness of chlorine in sterilization (Mitchell, 1972).

1-2-9-1-13 **Nitrate (NO₃⁻):**

Made up most of the nitrates in the groundwater from the remains of living organisms, manure, nitrate fertilizer and some plants convert air nitrogen into nitrate and supplied to the soil. There are also some bacteria that oxidize ammonia in the soil to nitrite and then to nitrate, this process called nitrification process (Boyd, 2000).

Do not constitute nitrates alone a threat to humans and animals, but the danger lies in derivatives that turn by microorganisms present in the gastrointestinal tract, including derivative Amin nitrous a carcinogen as well as hydroxyl Amin that results from some types of bacteria that are active on nitrates and cause genetic mutations (Al-Obaidy, 2008).

1-2-9-1-14 **Chemical Oxygen Demand (COD):**

The COD test is applicable to almost any aqueous sample as an index of pollution. It is used to determine the amount of oxidizable organic matter in effluents, it is now the most widespread procedure employed for environmental monitoring. Because of its unique chemical properties, the
dichromate ion (\(\text{Cr}_2\text{O}_7^{2-}\)) is the specified oxidant, and is reduced to the chromic ion (\(\text{Cr}^{3+}\)). Both organic and inorganic components of a sample are subject to oxidation, but in most cases the organic component predominates and is of the greater interest (Anon, 2007).

**Table (1-4): Iraqi, WHO and American Standards For River Water Quality.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Iraq 1967 For Rivers water</th>
<th>Iraq 1967 Wastewater discharged to the watercourse</th>
<th>WHO For Rivers water</th>
<th>American Standard For Rivers water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp.</td>
<td>°C</td>
<td>-</td>
<td>less 35</td>
<td>less 35</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>6-9.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>DO.</td>
<td>mg/l</td>
<td>More 5</td>
<td>-</td>
<td>-</td>
<td>More 5</td>
</tr>
<tr>
<td>BOD5</td>
<td>mg/l</td>
<td>less 5</td>
<td>less 40</td>
<td>less 3</td>
<td>less 5</td>
</tr>
<tr>
<td>Turbidity</td>
<td>N.T.U</td>
<td>25</td>
<td>-</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>Conductivity</td>
<td>µs/cm</td>
<td>-</td>
<td>-</td>
<td>250</td>
<td>-</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/l</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>500</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/l</td>
<td>-</td>
<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>T.H</td>
<td>mg/l</td>
<td>-</td>
<td>-</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Mg(^{2+})</td>
<td>mg/l</td>
<td>-</td>
<td>-</td>
<td>50-125</td>
<td>-</td>
</tr>
<tr>
<td>Ca(^{2+})</td>
<td>mg/l</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>NO(_3^-)</td>
<td>mg/l</td>
<td>15</td>
<td>50</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>CL(^-)</td>
<td>mg/l</td>
<td>200</td>
<td>600</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>-</td>
<td>less 100</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Heavy Metals (HMs):

HMs can be defined in several ways, the HMs are a positive ions in solution and they have a specific gravity of five times greater than that of water. However, they represent a common type of chemical pollution in water (Duffus, 2002). While Kim et al. (2000) define heavy metals as a group of chemical elements that have a specific gravity greater than 5 gm/cm$^3$.

Some well-known toxic metallic elements with a specific gravity that is 5 or more times that of water are iron, 7.9; cadmium, 8.65; lead, 11.34; nickel, 8.90; zinc, 7.133; mercury, 13.546; and arsenic, 5.7 (Al-Tameemi, 2010).

Such property, made them stable elements, and bio-accumulative. HMs have no function in the body and can be highly toxic. They are taken into the body via inhalation, ingestion, and skin absorption (IOM, 2001).

From the biological view (Foulkes, 2000), the HMs may be divided into four classes:

a. Class A: This group represents the iron element, which is essential for life with high concentration.

b. Class B: The elements that do not have a clear biological role, which when low concentrations are non-toxic or low such as: strontium.

c. Class C: includes elements such as: zinc, copper, nickel, cobalt, Molybdenum, and chromium which are all essential, but in small quantities for many of revival, but at high concentrations become very toxic.

d. Class D: includes elements that even when low concentrations can be toxic and have no clear biological functions include elements such as: lead, uranium, mercury and cadmium.

Environmental Pollution with Heavy Metals
Human exposure to heavy metals raised dramatically in the last 50 years, as a result of an exponential increase in the use of HMs in industrial processes and products (WHO, 2006).

HMs pollution is one of the most serious environmental problems facing life on earth, since it influences all living organisms in aquatic, terrestrial and air habitats (Vieira & Volesky, 2000). In the aquatic system, it has become a serious threat today and of great environmental problem because they are non-biodegradable, thus persistent in the environment. Moreover, metals are mobilized and carried into food web as a result of leaching from waste dumps, polluted soils and water. The metals increase in concentration at every level of food chain and are passed onto the next higher level—a phenomenon called biomagnification (Paknikar et al., 2003).

In recent years, drinking water standards are enforced, but fishing water, soil and irrigation systems may be exposed to large amounts of heavy metals. Using contaminated water for propagation as well as, applying sewage sludge to agricultural land as a fertilizer, sometimes causing phytotoxic effects as a result of metal accumulation in soils that lead to contaminating the food products which finally may be distributed to the people and the end result still affects public health (Hetzer et al., 2006).

Therefore, it is necessary for the present and future of public health that, people are not exposed to excessive levels of heavy metals in their diet (Omran, 2010).

1-2-9-2-2 Heavy metals toxicity symptoms

The association of symptoms indicative of acute toxicity is not difficult to recognize because the symptoms are usually severe, rapid in onset, and associated with a known exposure or ingestion (CDC, 2005). The symptoms of toxicity resulting from chronic exposure (impaired cognitive, motor, and language skills, learning difficulties, nervousness, emotional instability, and insomnia, nausea, lethargy, and feeling ill) are also easily
recognized; however, they are much more difficult to associate with their cause. Symptoms of chronic and acute exposure are very similar to symptoms of other health conditions and often develop slowly over months or even years (WHO/UNECE, 2006).

Much of the damage produced by toxic metals stems from the proliferation of oxidative free radicals they cause. A free radical is an energetically unbalanced molecule, composed of an unpaired electron that "steals" an electron from another molecule to restore its balance. Free radicals occurs naturally when cell molecules react with oxygen (oxidation) but, with a heavy toxic load or existing antioxidant deficiencies, uncontrolled free-radical production occurs (Tremeller, 2008). Unchecked, free radicals can cause tissue damage throughout the body; free-radical damage underlies all degenerative diseases. Antioxidants such as vitamins A, C, and E curtail free-radical activity (Krishnamurthy et al., 2007).

The net toxic manifestations produced by multiple exposures should, therefore, be different from those produced by a single factor as a result of their additive, synergistic or antagonistic action even though a metal may not exist in sufficient amounts to cause any disability, the toxicity could result when a second factor is also present (Wennberg et al., 2006).

The following paragraphs give a brief description of the harmful effects and applications of some heavy metals (Table 1-5):

1-2-9-2-3 Iron:

It is one of the most metals crustal abundance, and be more than 5% of the Earth's crust (Wiskinson Department of Natural Resource, 2005). Also it is found in natural freshwater levels ranging between 0.5 - 50 mg/l, acquires water bitter taste when it contains iron concentration higher than 2 mg/l, and can work on colouring clothes, ceramic pots when using this water for washing (Al- Fatlawi, 2007). And is one of the essential elements in human life for his role in the transport of oxygen in the blood and its entry in the formation of a group of enzymes, what is responsible for the construction of DNA (Golter & Mahler, 2006). Iron available in drinking water as a result of its use as an agglomerated material or as a result of rust and devour iron pipe through the process of distribution of water in the network (WHO, 1995). And the iron play an important role in the growth of iron bacteria, which working in oxidized to the ferric, leading to deposition
on the walls of the tubes. WHO (1996) and The Iraqi Standards No. 417 of (1974) and the first update (2001) has selected the proportion of iron in drinking water by no more than 0.3 mg/l. and if has increased amounts of exposure from the allowable limits can cause tissue destruction a result be free radicals even keep human exposure to high concentrations of iron can lead to entry into a coma and respiratory failure leading eventually to cardiac arrest (Emerit et al., 2001).

1-2-9-2-4 Cadmium:

Cadmium occurs in the Earth's crust at very low rate that is not measurable, while at sometimes reaches to less than 0.001 mg/l. It’s one of dangerous and polluting elements because of its ability to accumulate in the bodies of living organisms: animal, plant, and especially human, as it accumulates in the liver and kidney, in Japan the discharge of wastewater into Jintsu River in Toyama city from fluxing and mining factory and used the river water in irrigation rise fields lead to increase Cd in 1947 causing Itai itai disease and mortality for more than hundred people late in 1965 and syndromes appeared in bones (Al-Saadi, 2006).

1-2-9-2-5 Lead:

The greatest exposure to lead is swallowing lead paint chips or breathing in lead dust. But lead in drinking water can also cause a variety of adverse health effects. In babies and children, exposure to lead in drinking water above the action level of lead (0.015 mg/l) can result in delays in physiological and mental development, along with slight deficits in attention span and learning abilities, adults who drink this water over many years could develop kidney problems or high blood pressure (EPA, 2009). Generally lead is poisoning to the animal and plant, but for the microorganism the modern studies have showed that resistant strains to lead, and lead are generally not toxic to the microorganism, there compound on the contrary mercury compounds and chromium do not use as biological pesticides (EU commission, 2002).

1-2-9-2-6 Nickel:

Nickel present in the rocks above the basal, when nickel present in drinking water in concentrations higher than the permissible limits causes multiple diseases, such as: nausea, intestinal disorders and lung cancer
(WHO, 1984). Nickel like copper, iron and cobalt it increased solubility at pH decrease (Boyd, 2000).

1-2-9-2-7 Zinc:

One of the most elements widespread on earth as there is in the air, water and soil and in all foods. It is necessary for the body in small quantities and as very essential of the vital activities organization within human body, and also has the effect of the process of protein synthesis, as Co-factor of many enzymes that regulate cell growth and the level of hormones, and also contributes to the regulation of gene expression (Dimirkou, 2007). But if the concentration increased the limit in the water it causes the bitter taste of water and may cause skin diseases may lead to death, and this is what happened in many areas of Bangladesh (Tvinnereim, 1999).

May return environmental pollution with element zinc to some industries such as the production of dyes, plastics, rubber, ceramics and batteries also enters in the composition of some alloys such as bronze, pesticides and cosmetics protection against sunburn and inhibitors sweating and some types of medicines, as well as the impact of transport and waste incineration in increased concentration of this element in a vital ecosystem (Barakat, 2007).

Table (1-5): Iraqi, WHO and American Standards for River Water Quality.

<table>
<thead>
<tr>
<th>HMS (mg/l)</th>
<th>Iraq 1967 For river water</th>
<th>Iraq 1967 Wastewater discharged to the watercourse</th>
<th>WHO For river water</th>
<th>American Standard For river water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>0.3</td>
<td>2</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.005</td>
<td>0.01</td>
<td>0.003</td>
<td>0.005</td>
</tr>
<tr>
<td>Lead</td>
<td>0.05</td>
<td>0.1</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.1</td>
<td>0.2</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.5</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

1-2-9-3 Microbial properties of water

1-2-9-3-1 Total Bacterial Count (T.B.C):

It is an important test in the microbial water tests which gives an estimate of the total number of bacteria in the water sample, which is possible to develop into visible colonies on the nutrient agar under the described conditions of temperature and duration of incubation (EPA,
2006). This test is an evaluation of efficiency of water treatment processes especially the efficiency of the sterilization process (Al-Razzaq, 2011).

In general, it measures water quality in the distribution network (WHO & OECD, 2003) and evidence of the quality of water treatment process and safety of distribution systems (Hunter, 2003) and the suitability of water for drinking and food industries and an important indicator of the changes as possible to occur in water quality during the stages of storage and distribution, and detection of loss of chlorine purification evidence, and the presence of high levels of organic matter and sediments (Leclerc, 2003), But it does not provide evidence of the need for a health risk or faecal pollution. However, the special microbial quality it’s part of aerobic bacteria as possible to cause injury to a group of people who are characterized by poor immunity against diseases (WHO, 2006-a) (Table 1-6).

1-2-9-3-2 Total Coliform (TC):

The coliforms were defined as Gram-negative, non-spore-forming, facultative anaerobic bacilli that ferment lactose with production of acid and gas within 48 hours at 35-37 ºC (EPA, 2006). Coliform organisms better referred to as total coliforms to avoid confusion with others in the group. The total coliform group include these genera of the Enterobacteriacease family: Citrobacter, Enterobacter, Escherichia, Hafnia, Klebsiella, Serratia, and Yersina (Gerardi, 2006), and are not an index of faecal pollution or of health risk, but can provide basic information on source water quality (Al-Zubaidi, 2011).

Coliform bacteria are a group of bacteria present in great quantities in human feces. Total coliforms have long been utilized as a microbial measure of drinking water quality, largely because they are easy to detect and enumerate in water (Alley, 2007).

1-2-9-3-3 Faecal Coliform (FC):

Faecal Coliforms (FC) are a subgroup of total coliforms consisting mainly E. coli, Enterobacter, and some Klebsiella. They inhabit the intestines of warm-blooded animals, because they can grow and ferment lactose at a relatively high temperature 45 ºC (Nollet, 2007). It is a good indicator of faecal contamination because have species quality such as easy of detection of it and permanent presence and in large numbers in faecal
material (UNICEF, 2008). That are many sources of organic waste water containing bacterial communities from different sources, and the microbiological standards should be completely free drinking water of any bacteria that indicate contamination of water through human waste (Omar, 2006). The *E. coli* best evidence of faecal contamination according to (USEPA, 2005; WHO, 2006-b) because of:

   a. Their presence in large numbers in human feces and warm-blooded animals.
   b. Speed diagnosed.
   c. Do not grow in water not contaminated naturally.
   d. Present in the water and the isolated method similar to isolated pathogenic microorganism living in water.

**1-2-9-3-4 Total and Faecal Streptococci (TS & FS):**

Unlike the Coliform bacteria, they are gram positive and also tend to live longer in water than coliforms. Faecal streptococci have been used as indicators of water faecal contamination in water because presence in the intestines of humans and animals, as well as its presence in the soil and on plants and some insects (APHA, 2005). This group includes many bacteria species in the genus *Streptococcus* such as, *S. faecalis*, *S. bovis*, *S. equines*, *S. avium*, *S. faceium*, and *S. gallinarum* that are normally found in feces and gut of warm-blooded animals (Nollet, 2007).

**Table (1-6): Bacteriological characteristics of the surface water** *(Mahmood, 1988).*

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Allowable concentration</th>
<th>Desirable concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coliform group</td>
<td>1000/100 ml</td>
<td>&lt; 100 / 100 ml</td>
</tr>
<tr>
<td>Faecal Coliform</td>
<td>2000/100 ml</td>
<td>&lt; 100 / 100 ml</td>
</tr>
<tr>
<td>Streptococcus</td>
<td>2000/100 ml</td>
<td>&lt; 100 / 100 ml</td>
</tr>
</tbody>
</table>
The Study Area

Baghdad Medical City established in (1970) including several hospitals and situated in Bab Al-Muadham, Baghdad, Iraq. It’s on the east bank of the Tigris river (Rusafa side) and located between Sarafiya bridge and Bab Al-Muadham bridge (Iraqi Ministry of Environment, 2009).

Medical City Hospitals Survey Table (Appendix-1).

These medical centres and hospitals discharge the liquid waste directly into the river without any treatment. Once to twice daily (in the morning and in the evening), these disposal places contain many trees, dirty and algal growth - but no medical, offensive material like (Syringe, needle, blades ... etc.).

This study was carried out from October 2012 to September 2013. Five stations were selected for sampling to make bacteriological and physicochemical studies (Fig. 2-1):

Station 1: 500 M. beyond Medical City (Station 2) – as a control.

Station 2: Discharge point of Medical City (Appendix-2).

Station 3: 500 M. after Station 2.

Station 4: 2000 M. after Station 2.

Station 5: (Al-Wathba water intake) 70 M. beyond station-2 (Appendix-3). Sampling from this station was according to being situated between possible contaminated site that of control site.
2-2 Materials:

2-2-1 Apparatuses and Equipments:

Table (2-1): Apparatuses and equipments used in this study are:

<table>
<thead>
<tr>
<th>No.</th>
<th>Instruments</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH-meter</td>
<td>Hanna (Mauritius)</td>
</tr>
<tr>
<td>2</td>
<td>Turbidity meter</td>
<td>Hanna (Hungary)</td>
</tr>
<tr>
<td>3</td>
<td>Autoclave</td>
<td>Hirayama (Japan)</td>
</tr>
<tr>
<td>4</td>
<td>Sensitive Balance</td>
<td>Metzertoleno (Switzerland)</td>
</tr>
<tr>
<td>5</td>
<td>Incubator</td>
<td>Hirayama (Japan)</td>
</tr>
<tr>
<td>6</td>
<td>Drying Oven</td>
<td>Memmert (Germany)</td>
</tr>
<tr>
<td>No.</td>
<td>Materials</td>
<td>Company – origin</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Manganese Sulphate (MnSO₄)</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>2</td>
<td>Iodide Azide</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>3</td>
<td>H₂SO₄</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>4</td>
<td>Sodium Thiosulphate</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>5</td>
<td>Sodium hydroxide (NaOH)</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>6</td>
<td>Erichrom black T</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>7</td>
<td>Ethylene Diamine Tetra Acetic Acid (EDTA)</td>
<td>BDH (England)</td>
</tr>
</tbody>
</table>

2-2-2 Chemical compounds:

Table (2-2): chemicals used in the study

<table>
<thead>
<tr>
<th>No.</th>
<th>Materials</th>
<th>Company – origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manganese Sulphate (MnSO₄)</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>2</td>
<td>Iodide Azide</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>3</td>
<td>H₂SO₄</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>4</td>
<td>Sodium Thiosulphate</td>
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</tr>
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<td>5</td>
<td>Sodium hydroxide (NaOH)</td>
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<td>6</td>
<td>Erichrom black T</td>
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<tr>
<td>7</td>
<td>Ethylene Diamine Tetra Acetic Acid (EDTA)</td>
<td>BDH (England)</td>
</tr>
<tr>
<td>No.</td>
<td>Culture media</td>
<td>Company / Origin</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>1</td>
<td>Nutrient agar</td>
<td>Himedia (India)</td>
</tr>
<tr>
<td>2</td>
<td>MacConkey agar</td>
<td>Himedia (India)</td>
</tr>
<tr>
<td>3</td>
<td>MacConkey Broth</td>
<td>Himedia (India)</td>
</tr>
</tbody>
</table>

2-2-3 Culture Media:

2-2-3-1 Ready culture media:

Table (2-3): Ready culture Media used in the study

<table>
<thead>
<tr>
<th>No.</th>
<th>Culture media</th>
<th>Company / Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nutrient agar</td>
<td>Himedia (India)</td>
</tr>
<tr>
<td>2</td>
<td>MacConkey agar</td>
<td>Himedia (India)</td>
</tr>
<tr>
<td>3</td>
<td>MacConkey Broth</td>
<td>Himedia (India)</td>
</tr>
</tbody>
</table>

These media prepared according to the manufactured company's instructions, sterilized by autoclave at temperature 121 °C and 15 Par for 15 minutes.
2-2-3-2 Prepared culture media:

- **Azide Dextrose Broth**

  (15gm trepton + 4.5gm Beef Extract + 7.5gm Dextrose + 7.5gm Sodium chloride + 0.2gm Sodium Azide).

  The mixture was dissolved in 100 ml Distilled water and adjust pH at 7.2 then stain added (Bromo Cresol Purpule 0.1%) and sterilized by autoclave at 121 ºC and 15 Par for 15 min (APHA, 1976).

2-2-4 Stains, reagents and solutions:

Grams stain, reagents and other solutions prepared accordance to (APHA, 2005).

2-3 Sample collection:

Samples were collected monthly from the four stations marked on the map (Fig. 2-1), and seasonally from the fifth station. The samples were taken at depth 10-20 cm surface water approximately, two repeating samples for months, sterilized dark Winkler bottles 250 ml use for Dissolve Oxygen and Biological Oxygen Demand, Sterilized glass bottles 250 ml used for bacteriological analysis and kept them in a cool box until reach to the laboratory at time not reach 3 hours, sterilized plastic bottles used for physical, chemical and Heavy metals analysis (APHA, 1998).

2-4 Methods:

2-4-1 Sterilization:

1- Wet Sterilization :

   Culture media sterilized by used Autoclave 121°C, 15 Par for 15 min.

2- Dry Sterilization :

   All glassware used sterilized by oven at 200°C for 2 hours.

2-4-2 Physico-chemical measurements:

2-4-2-1 Temperature
The air and water temperature was measured by a mercury thermometer, at depth 10 -15 cm (APHA, 1985).

2-4-2-2 Hydrogen Ion (pH)

The pH values were measured by a pH-meter (AOAC, 2005).

2-4-2-3 Electrical conductivity (EC)

Electrical conductivity measured by a portable conductivity meter (µs/cm) (HP Technical Assistance, 1999).

2-4-2-4 Turbidity

Water turbidity was measured in the laboratory by turbidity meter (NTU) (APHA, 2005).

2-4-2-5 Salinity

According to (APHA, 1998) measured Salinity by EC Result:

\[
\text{Salinity (ppt \%o)} = \frac{(EC \, (\mu s/cm) – 14.78)}{1589.08}
\]

2-4-2-6 Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD)

Water samples for Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) were collected in sterile dark Winkler bottles 250 ml, they were washed and sterilized by the oven for 4 hrs. at 200 °C. Oxygen fixation was done at field by adding 2 ml of Manganese Sulphate and Iodide Azide, and in the laboratory adding 2 ml of H₂SO₄ to the samples which fixed in field. Then titrate with Na-Thiosulfate (0.0125 N) and using starch as indicator, for measured DO the following equation was used:

\[
DO \, \text{mg/l} = \frac{V_2 \times 8000 \times 0.0125}{V_1 - 1.3}
\]
V₂: volume of titrate

V₁: volume of sample

BOD₅ dark bottles were kept in the incubator at 25±1°C for 5 days and measured by Winkler method, BOD was measured as the following:

\[ \text{BOD}_5 = \text{DO initial} - \text{DO after 5 days} \] (APHA, 1998).

2-4-2-7 Chloride ion (Cl⁻):

Chloride ion concentration was measured according to the method called Argentometric Nitrate Method, where 10 ml of the sample diluted to 100 ml of distilled water, and 1 ml of potassium chromate solution as an indicator was added, the sample titrated against silver nitrate solution (0.0141 N) until the appearance of reddish - brown colour, then the formula described in APHA (2005) was applied to calculate the concentration of chloride ion, as follows:

\[ \text{Cl}^- \text{ mg/l} = \frac{(A-B)(N) \times 35450}{V} \]

Where A = ml titration for sample.

\[ B = \text{ml titration for blank} \]

\[ N = \text{normality of silver nitrate}. \]

\[ V = \text{ml of sample}. \]

2-4-2-8 Total Hardness, Calcium and Magnesium ion:

The method described in APHA (2005) was used to measuring the values of Total Hardness, by taking 10 ml of the sample and diluted to 50 ml with distilled water, then 1 ml of ammonia regulator solution was added where the pH =10. After the addition of a few dry indicator (Erichrom
black T) use as reagent and titrated against EDTA solution (0.05 M), and calculated by the following equation:

Total hardness as CaCO₃ mg/l = A × B × 1000 / V

Where A = ml titration for sample.
B = mg of calcium carbonate equivalent 1ml of EDTA titrated.
V = ml of sample.

Calcium ion concentration calculates by the method called EDTA Titrametric Method (APHA, 2005). Where 10 ml of the sample diluted to 50 ml by distilled water, then 2 ml of NaOH (1 N) added to the sample to adjust the pH to 12-13, meroxide reagent added in amount of 0.2 gm. The samples titrated against (0.01M) EDTA-Na₂ until the colour changes from pink to purple which indicate to the end of the reaction. Calcium ion was calculated according to the following equation:

Ca⁺² mg/l = A × B × 40.08 / V

Where A = ml of titration for sample
B = gm of calcium carbonate equivalent of 1 ml of EDTA.
V = ml of sample.

Magnesium ion concentration was calculated according to the equation described in (APHA, 1998; AOAC, 2005):

Mg⁺² mg/l = (Total hardness - Calcium hardness) × 0.243

2-4-2-9 Total Suspended Solids (TSS) and Total Dissolved Solids (TDS):

The method approved by APHA (1999) was counted to estimate the Total Suspended Solid, that’s by drying filter papers openings diameter of 0.45 micron, then the papers placed in the oven at temperature between
103-105 °C for one hour, cooled to room temperature in a glass bell, weighed by sensitive balance.

Flasks of capacity 500 ml dried and 250 ml of the sample filtrated through it, the suspended solids separate and settle on the filter paper, then the paper inserted in the oven again at the same temperature for an hour then weighed again and applied the following equation:

\[
TSS \text{ mg/l} = \frac{(A - B) \times 1000}{V}
\]

Where \( A \) = weight of filter paper after filtration.

\( B \) = weight of filter paper.

\( V \) = ml of sample

Total dissolved solids concentrations calculated according to the equation in (HP Technical Assistance, 1999; EPA, 2001).

\[
TDS \text{ mg/l} = 0.64 \times EC \mu s / cm.
\]

2-4-2-10 Nitrate (NO\(_3^-\)): 

Nitrate measured according to APHA (2005) by using 2 ml HCl (1N) added to the diluted sample (5 ml of sample to 50 ml by using de-ionised water) then measured by UV-spectrophotometer at wave length 220 nm. Results were recorded in unit mg/l.

2-4-2-11 Chemical Oxygen Demand (COD):

Chemical oxygen demand was determined after oxidation of organic matter in strong acid medium by K\(_2\)Cr\(_2\)O\(_7\) at 148°C, with back titration with ferrous ammonium sulphate (0.01 M) after adding 2-3 drops of ferrion indicator, colour change from blue-green to reddish-brown indicated the end point (APHA, 1998). Results were expressed as mg/l. COD value was calculated by the equation:
\[ COD = \frac{(a - b) \times c \times 8000}{v} \]

Where:

- \( a \) = ferrous ammonium sulphate (ml) used for blank
- \( b \) = ferrous ammonium sulphate (ml) used in sample
- \( c \) = molarities (mol.l\(^{-1}\)) of ferrous ammonium sulphate
- \( v \) = volume of sample (ml)
- 8000 = milliequivalent weight of oxygen \( \times 1000 \) ml/l

### 2-4-3 Heavy Metals test:

Flame atomic absorption spectrometry (FAAS) is a common analytical technique for the determination of metals. For the measurement, the sample solution was directly aspirated and atomized in flame. A light beam from a hollow cathode lamp made of the same element being determined was passed through the flame and into monochromate to detect the amount of reduction of the high intensity due to atomic absorption and this could directly related to the amount of element in the sample.

The FAAS was calibrated by standard solution for each element. The standard solution was prepared from a known weight of the element and then standard curve was done. The calibration curve was plotted for each element measured in all samples (APHA, 2003).

### 2-4-4 Microbial tests:

#### 2-4-4-1 Total Bacterial Count (T.B.C):

The method of Pour plate mentioned in AOAC (2005) and APHA (2005) was used, by shaking the sample bottle 25 times up and down to ensure the mixing of contents. All testing steps have been done in a
sterilized conditions near the source of the flame, make serious dilution of samples by normal saline solution ranged between \((10^{-4} - 10^{-5})\) depending on the degree of contamination of the sample. One ml of diluted sample transferred to a sterilized petri dish by repeating each dilution, then 10-15 ml of the nutrient dissolved media cooled to a temperature of 44-46 °C and poured to each plate, the dish was moving in a circular motion several times to ensure homogeneity of the sample with the medium, the plates were left until the hardening of the medium, then they were incubated upside down in the incubator at a temperature of 37 °C for 48 hours, after the period of incubation the total number of each replicates of the sample was counted, the range was extracted and multiplied by the inverse of dilution to calculated the total number of bacteria in 1 ml of the sample and recorded the result by the unit of (cell/1ml).

**2-4-4-2 Total Coliform (TC) & Faecal Coliform Count (FC):**

Most Probable Number (MPN) procedure described by APHA (1999), used as make serious dilution of samples by normal saline solution. Using MacConkey broth as cultivated medium with Durham tubes for gas detection, tubes incubated at 37±0.5 °C and 44.5±0.25 °C for 24 hrs.

**2-4-4-3 Streptococci & Faecal Streptococci (FS):**

MPN procedure was used as described by APHA (1976), to make serious dilution of samples by normal saline solution. Using Azide Dextrose broth for both Streptococci and Faecal Streptococci bacteria as cultivated medium, tubes incubated at 37±0.5°C for 24-72 hrs. and 44.5±0.25°C for 24-48 hrs.

The result of (2-4-4-2) and (2-4-4-3) calculated by equation:

\[\text{No. of cells/ml} = \text{MPN} \times \text{reverse of mild dilution}.\]
**2-4-4-4 FC: FS Ratio:**

To determine the pollution origin, when the FC: FS Ratio $<1$ is indicated for water pollution of animal source, and whereas FC: FS Ratio $\geq 1$ is indicated for water pollution of human source (Geldrich, 1967).

**2-4-4-5 Diagnosis:**

Diagnoses were depended on culture, microscope and API system (Appendix: 4, 5 and 6).

**2-4-4-6 Statistical Analysis**

The Statistical Analysis System- SAS (2010) was used to effect of factors (station & month) in study parameters. Least significant difference – LSD test was used to significant compare between means this study.
physicochemical properties:
3-1-1 Air and Water Temperature:

Water temperature is an important factor that affects the rate of many biological and chemical processes in the water way and the amount of oxygen which dissolve in the water. The well being of aquatic life, from bacteria to fish, is influenced by temperature. It is probably the most important environmental variable; it affects activities, growth, feeding, reproduction, distribution and migratory behaviours of aquatic organisms (Suski et al., 2006). Biochemical reactions affected by temperature when a rise of 10°C leading to an approximate doubling of the reactive rate (EPA, 2001).

The air temperature values in this study were varied from the lowest value 12 °C which was recorded at station 1 in January and the highest value 33 °C was observed in August at station 4. While the water temperature values were varied from lowest value 11°C in January in all stations and the highest value was 32 °C at station 4 in August (Fig. 3-1 and 3-2), Temperature recorded at 7 a.m.

The statistical analysis showed that there was a significant difference at (P˂0.05) in air and water temperature among months, while no any significant differences among stations (Table 3-1). The direct correlation between air and water temperature (r = 0.980) was observed in the present study, while the inverse correlation was found between water temperature and DO. (r= -0.731) (Table 3-2).

It is clear from current results that the highest value of water and air temperature during summer and the lowest value during winter, high
temperature in dry seasons than in wet seasons could be due to longer and higher sun light intensity (Hart and Zabbey, 2005).

It is clear that Tigris river was affected by the surrounding air temperature, the results showed high temperature in summer months and low temperature in winter months. These findings had also achieved at same conclusion with other studies in same area (Al-Lami et al., 1999; Ismail et al., 2000; Ahmed, 2012), and in different parts of the world (Odum, 1971; Shekha, 2008). There are no effects of Medical city discharge point on the temperature of the river.

![Figure 3-1: Monthly variation in Air Temperature during 2012/2013](image1)

![Figure 3-2: Monthly variation in Water Temperature in Tigris river during 2012/2013](image2)
Table (3-1): Minimum and maximum (First Line), mean and standard deviation (Second Line), for physical and chemical characteristics in studied stations during 2012-2013.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>St.1</th>
<th>St.2</th>
<th>St.3</th>
<th>St.4</th>
<th>St.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temperature °C</td>
<td>12 – 32</td>
<td>13 – 32</td>
<td>13 – 32</td>
<td>13 – 33</td>
<td>12 – 29</td>
</tr>
<tr>
<td></td>
<td>22.91 ± 1.54</td>
<td>23.37 ± 1.09</td>
<td>23.83 ± 1.58</td>
<td>24.33 ± 1.37</td>
<td>22 ± 1.27</td>
</tr>
<tr>
<td>Water Temperature °C</td>
<td>11 – 30</td>
<td>11 – 31</td>
<td>11 – 31</td>
<td>11 – 32</td>
<td>11 – 27</td>
</tr>
<tr>
<td></td>
<td>21.25 ± 1.23</td>
<td>21.83 ± 0.98</td>
<td>22 ± 1.06</td>
<td>22.25 ± 1.29</td>
<td>21 ± 1.04</td>
</tr>
<tr>
<td>pH</td>
<td>6.1 – 9</td>
<td>6.02 – 8.7</td>
<td>6.52 – 9</td>
<td>6.64 – 9.1</td>
<td>5.95 – 7.4</td>
</tr>
<tr>
<td></td>
<td>7.97 ± 0.54</td>
<td>7.35 ± 0.62</td>
<td>7.69 ± 0.68</td>
<td>7.76 ± 0.51</td>
<td>6.79 ± 0.57</td>
</tr>
<tr>
<td>Turbidity NTU</td>
<td>7.4 – 51</td>
<td>16.4 – 250</td>
<td>7.5 – 135</td>
<td>7.4 – 64</td>
<td>22 – 60</td>
</tr>
<tr>
<td></td>
<td>18.91 ± 0.41</td>
<td>61.50 ± 1.04</td>
<td>40.48 ± 0.74</td>
<td>28.35 ± 0.58</td>
<td>36.5 ± 0.44</td>
</tr>
<tr>
<td>D.O mg/l</td>
<td>6.4 – 11.5</td>
<td>0.3 – 9.4</td>
<td>3 – 11.5</td>
<td>3.5 – 8.8</td>
<td>6 – 8</td>
</tr>
<tr>
<td></td>
<td>7.85 ± 0.52</td>
<td>4.86 ± 0.33</td>
<td>6.88 ± 0.71</td>
<td>6.48 ± 0.53</td>
<td>6.9 ± 0.35</td>
</tr>
<tr>
<td>BOD mg/l</td>
<td>0.6 – 5.2</td>
<td>0 – 6</td>
<td>1.1 – 6.5</td>
<td>0.8 – 4.8</td>
<td>1.1– 3.8</td>
</tr>
<tr>
<td></td>
<td>2.58 ± 0.07</td>
<td>3.05 ± 0.02</td>
<td>3.08 ± 0.02</td>
<td>2.6 ± 0.02</td>
<td>2.2 ± 0.02</td>
</tr>
<tr>
<td>TDS mg/l</td>
<td>339 – 492.8</td>
<td>384 – 1081</td>
<td>346 – 837.7</td>
<td>356.4 – 833</td>
<td>403.2 – 707.2</td>
</tr>
<tr>
<td></td>
<td>425.22 ± 20.5</td>
<td>708.14 ± 33.7</td>
<td>505.14 ± 19.6</td>
<td>495.69 ± 22.9</td>
<td>523.5 ± 16.3</td>
</tr>
<tr>
<td>E.C. µS/cm</td>
<td>530 – 770</td>
<td>600 – 1690</td>
<td>541 – 1309</td>
<td>557 – 1302</td>
<td>630 – 105</td>
</tr>
<tr>
<td></td>
<td>664.75 ± 22.7</td>
<td>1106.75 ± 42.91</td>
<td>789.41 ± 22.07</td>
<td>774.66 ± 21.68</td>
<td>818 ± 19.4</td>
</tr>
<tr>
<td></td>
<td>Salinity ppt %o</td>
<td>TSS mg/l</td>
<td>T.H. mg/l</td>
<td>Ca++ mg/l</td>
<td>Mg++ mg/l</td>
</tr>
<tr>
<td>---------------------</td>
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<td>-------------------</td>
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<td>--------------</td>
</tr>
<tr>
<td></td>
<td>0.32 – 0.47</td>
<td>0.36 – 1.05</td>
<td>0.33 – 0.8</td>
<td>0.34 – 0.81</td>
<td>0.38 – 0.68</td>
</tr>
<tr>
<td></td>
<td>0.404±0.02</td>
<td>0.677±0.01</td>
<td>0.482±0.02</td>
<td>0.474±0.02</td>
<td>a</td>
</tr>
<tr>
<td>a</td>
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</tr>
<tr>
<td>0.36 – 0.81</td>
<td>0.476 – 800</td>
<td>665.8±7.3</td>
<td>320 – 655</td>
<td>55 – 355</td>
<td>210 – 610</td>
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<tr>
<td>0.36 – 1.05</td>
<td>456 – 896</td>
<td>686±9.2</td>
<td>590±10.8</td>
<td>420±17.4</td>
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<tr>
<td>0.33 – 0.8</td>
<td>476 – 800</td>
<td>665.8±7.3</td>
<td>320 – 655</td>
<td>55 – 355</td>
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<tr>
<td>0.33 – 0.81</td>
<td>456 – 896</td>
<td>686±9.2</td>
<td>590±10.8</td>
<td>420±17.4</td>
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<tr>
<td>0.38 – 0.68</td>
<td>400 – 730</td>
<td>590±10.8</td>
<td>346.25±12</td>
<td>46 – 63</td>
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</tr>
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<td>a</td>
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</table>

*Station that carrying similar character have no any significant difference between them.*
Table (3-2): The correlation among water parameters.

<table>
<thead>
<tr>
<th></th>
<th>Air Temp</th>
<th>Water Temp</th>
<th>pH</th>
<th>E.C.</th>
<th>Sal.</th>
<th>DO</th>
<th>BOD</th>
<th>Turbi.</th>
<th>TDS</th>
<th>TSS</th>
<th>TH</th>
<th>Ca</th>
<th>Mg</th>
<th>Cl</th>
<th>COD</th>
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<tbody>
<tr>
<td>Water Temp.</td>
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<tr>
<td>Sali.</td>
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<td>0.998</td>
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<tr>
<td>DO</td>
<td>-0.659</td>
<td>-0.731</td>
<td>-0.204</td>
<td>0.266</td>
<td>0.281</td>
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<tr>
<td>BOD</td>
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<td>0.182</td>
<td>0.520</td>
<td>0.525</td>
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<tr>
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<td>-0.198</td>
<td>-0.206</td>
<td>0.157</td>
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<tr>
<td>TDS</td>
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<td>0.999</td>
<td>0.998</td>
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<td>0.521</td>
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<tr>
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<td>-0.186</td>
<td>0.199</td>
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<td>TH</td>
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<td>0.054</td>
<td>0.706</td>
<td>0.694</td>
<td>0.212</td>
<td>0.234</td>
<td>-0.079</td>
<td>0.707</td>
<td>0.327</td>
<td></td>
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</tr>
<tr>
<td>Ca</td>
<td>0.145</td>
<td>0.204</td>
<td>0.277</td>
<td>0.518</td>
<td>0.542</td>
<td>0.019</td>
<td>0.184</td>
<td>-0.078</td>
<td>0.518</td>
<td>0.098</td>
<td>0.521</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>-0.166</td>
<td>-0.146</td>
<td>-0.122</td>
<td>0.544</td>
<td>0.516</td>
<td>0.260</td>
<td>0.176</td>
<td>-0.028</td>
<td>0.545</td>
<td>0.305</td>
<td>0.866</td>
<td>0.034</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Cl</td>
<td>-0.593</td>
<td>-0.582</td>
<td>-0.067</td>
<td>-0.072</td>
<td>-0.069</td>
<td>0.544</td>
<td>-0.440</td>
<td>0.012</td>
<td>-0.072</td>
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<td>0.305</td>
<td>-0.040</td>
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</tr>
<tr>
<td>COD</td>
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<td>0.347</td>
<td>0.082</td>
<td>0.373</td>
<td>0.367</td>
<td>-0.243</td>
<td>0.392</td>
<td>-0.198</td>
<td>0.374</td>
<td>-0.236</td>
<td>0.153</td>
<td>0.412</td>
<td>-0.028</td>
<td>-0.398</td>
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</tr>
<tr>
<td>NO₃</td>
<td>-0.319</td>
<td>0.463</td>
<td>0.222</td>
<td>0.298</td>
<td>0.302</td>
<td>-0.147</td>
<td>0.767</td>
<td>-0.101</td>
<td>0.299</td>
<td>-0.061</td>
<td>-0.145</td>
<td>-0.079</td>
<td>-0.099</td>
<td>-0.672</td>
<td>0.187</td>
</tr>
</tbody>
</table>

3-1-2 Hydrogen Ion (pH):

The pH value is the measurement of acidity and alkalinity of waters (Bee, 2005). Hydrogen ion concentration is one of the vital environmental characteristics which effect the survival, metabolism, physiology and growth of aquatic organisms (Lawson, 2011). pH represent the activity and effectiveness of the hydrogen ion in the water, and in general, most of the natural water tend to be alkaline because of the carbonates and bicarbonates (Liere et al., 1991; Al-Saadi & Mauloud, 1991).

The present study results showed that the highest value of water pH was 9.1 in July at station-4, which considered alkaline; while the lowest value was 6.02 in April at station-2, which slightly acidic (Fig. 3-3). The
statistical analysis showed a significant differences among months and among stations for water pH at (P<0.05) (Table 3-1). The direct correlation with water temperature (r= 0.617) was observed in present study (Table 3-2).

High pH during summer and autumn might resulted from the rate of photosynthesis by dense phytoplankton blooms and this leads to consumption of large amounts of carbon dioxide in water (Lawson, 2011), as well as the excessive using of CaCO₃ to control pipe corrosive (Morin, 2009), in addition to that the effects of sand storm which increasing CaCO₃ concentration in water (Johnson et al., 2009), also one of the important factors influencing water pH, was the rainfall which occurs during winter. The rain is naturally slightly acidic due to the carbon dioxide dissolved in it (WASC, 2002).

In the station-2, pH was 6.02 - 8.7 similar to hospital waste water in France, which is 6.26 – 8.52 (Emmanuel, 2002) which is lowest values might be due to the presence of pollution, or the degradation organic materials which produced dissolved carbon dioxide as a result of low temperature which lead to forming HCO₃⁻and increasing H⁺ ion (McCauley et al., 2009), pH higher than 7 but lower than 8.5 according to Abowei (2010) was ideal for biological productivity, but pH at 4 was detrimental to aquatic life. Iraqi natural water was weak alkaline which might be results from calcium salts that Iraqi soil rich with it (Hassan, 2004). In the Tigris, Euphrates, and Shatt al-Arab rivers seasonal variations were observed with the lower values during the winter and spring and higher values during summer and autumn (IMET and IF, 2005).

The present study ranges slightly above of those report by Al-Fatlawy (2007) who found pH values was ranged between (7.4- 8.2), Nashaat (2010) who found that pH values were between (7.4-8.8) in Tigris River, but agree with them that pH increase in summer and decrease in winter due to temperature and CO₂ solubility.
The minimum pH recorded in present study were within Iraqi, WHO and American standards, and the Maximum is above them, which was ranged between 6.5-8.5 (Table 1-4)

![Figure 3-3: Monthly variation of Hydrogen Ion in Tigris river during 2012/2013](image)

### 3-1-3 Electrical Conductivity (EC) and Salinity:

The electrical conductivity is a good mark to estimation of total dissolved substances in the water on the one hand and the purity of the water on the other hand, it’s one of the quick ways to note the changes that occur in the natural aquatic environment and the elements dissolved (APHA, 2005). Also it related to total dissolved solids, chlorides, and salinity. Salinity was a measure of the amount of salts in the water; salty water conducts electricity more readily than pure water. Therefore, electrical conductivity is routinely used to measure salinity (WASC, 2002).

The results indicated that the highest value of EC was 1690 µs/cm, and salinity was in 1.05 ‰ in November and September at Station-2. While the lowest values of EC was 537 µs/cm in January and salinity was 0.32 ‰ a gain in January and June at Station-1 (Fig. 3-4 and 3-5).The statistical analysis showed a significant differences among months for E.C. and salinity at (P<0.05), but no any significant differences among stations was observed except E.C.at station-2 (Table 3-1). Conductivity and
salinity showed a direct correlation with BOD, TDS, T.H, Ca and Mg (Table 3-2). However, the values of EC increased during summer and autumn and decreased during winter and spring that’s might be due to the high temperature during summer and autumn in Iraq which led to increase evaporation, then increase salts concentration as so as increase of many pollutants concentration, also the additional amount of calcium carbonate CaCO₃, then work on precipitating them on the pipes surfaces which cause the increase of EC in water.

Mustafa, (2012) showed that the range of EC value in Tigris river was 689-1386 µS/cm and salinity 0.44 - 0.887‰, while Hashim (2010) recorded that the maximum value of E.C. in Tigris river was 1515 µS/cm and salinity 0.969 ‰, whereas the minimum value for E.C. 953 µS/cm and salinity was 0.609 ‰, this results near to the present study finding. The salinity results were within the range of freshwater salinity that ranged from 0 to 3.5‰ (Pitt, 2000).
3-1-4 Turbidity:

The obtained results reveal that the highest value of turbidity was 250 NTU in February at station-2, while the lowest value was 7.4 NTU in June in station-1 (Fig. 3-6). The statistical analysis detected a significant differences among months and among stations at (P˂0.05), (Table 3-1).

The turbidity increased during rainy seasons was attributed to soil erosion in the nearby catchment and massive contribution of suspended solids from hospitals or factory sewage (Al-Obaidi, 2009). Surface runoffs and domestic wastes mainly contribute to the increased turbidity, and increased of water levels in winter and there movement lead to non precipitation of suspended solids (Gangwara et al., 2012). This study disagreed with the recent study of Rezooqy (2009) in Iraq, which found that Turbidity was increased during summer, Srivastava, et al., (2011) and Patel &Parikh (2013) studies in India. Nevertheless, agreed with Al-Fatlawi (2007) and Al-Shimary (2005), which found that the turbidity was increased in all locations during winter but decreased in summer and spring. Station-2 appears highest value in all study time because it’s discharge point.
3-1-5 Dissolved Oxygen (DO):

The present results showed that the highest value for DO was 11.5 mg/l at station-1 in December, while the lowest value was 0.3 mg/l at station-2 in November (Fig.3-7). The DO results from station-2 are lower than other station because the high discharge sewage. The statistical analysis revealed a significant differences at \( P < 0.05 \) in DO among months, but no significant differences among stations except station-2 (Table 3-1).

The concentration of dissolved oxygen in Tigris river raising in winter this may be due to the increase aeration because of rainfall, in addition to the decrease of temperature in winter that increase the oxygen solubility (Adeyemo et al., 2008). Higher water flow during winter is suggested to contribute significantly in elevating dissolved oxygen concentrations the disturbance of water could lead to the increase of dissolved oxygen in water (Tobin et al., 2001).

Then the decreasing in the dissolved oxygen rates in summer at Tigris river may be due to the raise of temperature to 40 °C that leads to decline dissolved oxygen concentration in water, as well as, the waste discharge of high inorganic matters, and the nutrients could lead to decrease in dissolved oxygen concentration as a result of the increased microbial activity occurring during the degradation of the organic matters by
self-purification (Dallas & Day, 2004). When the temperature increases the oxygen holding capacity of water decreases, which means that temperature plays a major role in the biological processes (Al-Saad et al., 2010).

Dissolved oxygen concentration in water play an important role in metabolic activity of all aquatic organisms (Wetzel, 2001). Iraqi, WHO and American standards for river water mentioned that the optimal values of DO was more than 5 mg/l (Table1-4), while USEPA (2000) mentioned that the minimum values for DO is 4.5mg/l, but UNESCO (2000) mentioned that DO concentration of 9 mg/l is optimal, while 7-8 mg/l considered acceptable, and 3.5-6 mg/l considered poor. In the present study Tigris river considered acceptable according to DO except in some months in study area.

The results of current study were similar to the studies of Wahab (2010) on Tigris river which recorded levels between 4-6.77 mg/l, the study of Hassan et al. (2010) on Euphrates River who recorded values between 3.1-13 mg/l, as well as the study of Ali (2010) on Greater Zab River. Also the study of Iqbal et al., (2004) on Soanriver - Pakistan, who found the values between 4.6-9.3 mg/l.

![Figure 3-7: Monthly variation in Dissolved Oxygen in Tigris river during 2012/2013](image)

3-1-6 Biological Oxygen Demand (BOD₅):
The current work has shown that the highest value of BOD was 6.5 mg/l in December at station-3, while the lowest value was zero in November at station-2 (Fig. 3-8). The results of statistical analysis refer that significant different at (P<0.05) between months but no any significant differences between stations (Table 3-1). The BOD results from station-2 were higher than other stations because the high discharge sewage.

Generally the increase of BOD in autumn and winter may be due to the organic matter which enters in large quantities with rainfall and increasing in water temperature start to decay the organic substances leading to decrease in DO value and increase BOD (Voulgaropoulos et al., 1987).

The results of this study were higher than that observed Al-Nimrawee (2005) found the range for BOD₅ was 0.9-3.5 mg/l in Tigris river, and Aziz (2006) found the range for BOD₅ was 1.3-4.6 mg/l in Greater Zab river, whereas it was lower than that reported by Abed Al-Razzaq (2011) with a range of 0.006-640 mg/l in Tigris river and Shekha (2008) found the range for BOD₅ was 0.4-38.8 mg/l in Greater Zab river. Unpolluted waters typically have BOD values of 2mg/l or less, while those receiving wastewaters may have value up to 10mg/l (Chapman, 1996).

![Figure 3-8: Monthly variation in Biological Oxygen Demand in Tigris river during 2012/2013](image)
Chloride ion (Cl⁻¹):

Chloride ion found in natural water in different concentrations, the presence of chlorides in the water is an indication that water pollution by sewage, which contains human urine that contains of chlorides that up to 6 g/day. **Excess presence of Chloride in water leads to gastrointestinal disease, diarrhea, and skin allergies (Cheepi, 2012).**

The present study result showed that the highest value of Cl⁻¹ was 190 mg/l in December at Station-2, while the lowest value was 35 mg/l in August at Station-1 (Fig. 3-9).

**The statistical analysis revealed a significant differences at (P<0.05)** in Cl⁻¹ among months but no any significant differences among stations was observed except with station-2 (Table 3-1). The direct correlation with TSS (r= 0.680), while the inverse correlation with air and water temperature (r= -0.593 and r= -0.582 respectively) was observed in present study (Table, 3-2).

Highest Cl⁻¹ values in winter because of raining and decrease in spring, and retrained to raise in summer because of dust storms in region (Wang et al., 2005). The Cl⁻¹ results from station-2 are higher than other station because the high discharge sewage.

The current results complied with those of other study of Al-Lami et al., (1996), who found that Cl⁻¹ values between 73-183 mg/L in Tigris river, but was lower than that reported by Abed Al-Razzaq (2011), recorded Cl⁻¹ values varied between 27.28-237.85 mg/l in Tigris river. The Cl⁻¹ concentration was within the permissible limit for Iraqi, WHO and American standards for river water, which was 200 mg/l (Table 1-4).
3-1-8 Total Hardness:

The current results found that the highest value for T.H. was 625 mg/l in January at Station 2, while the lowest value was 170 mg/l in June at Station 4 (Fig. 3-10). The statistical analysis showed a significant difference among months for T.H at (P<0.05), and a significant difference among stations except station 3 and 4 (Table 3-1). The direct correlation with E.C. and salinity ($r=0.706$ and $r=0.694$ respectively), was observed in present study (Table 3-2).

Means rates tend to decrease in spring and increase in summer due to the dust storms and sediment a large amount of dust particles which is rich in calcium carbonate also the age of the pies and its content of salts, and also high values in winter because the rains fall on the ground. Then increase of material in water in the lands next to the water sources (Skipton et al., 2004). This study agreed with the studies of (Al-Saady et al., 2000; Nada et al., 2002; Al-Fatlawy, 2007 and Rezooqy, 2009).

Kevin (1999) classified freshwater into four groups according to T.H: with less than 50 mg/l are soft, from 50 to 100 mg/l are moderate hardness, waters from 100 to 200 mg/l are hard, and waters hardness above 200 mg/l consider very hard. While USEPA (2000) classified waters according to
CaCO₃ as the following: 50-150 mg/l is moderator hard water, 150-300 mg/l hard water, and more than 300 mg/l very hard water. From these results, Tigris river water is considerable as moderate hard to very hard water because its range 170 - 625 mg/l, these results similar to Sharad (2004) found the hardness of Tigris river range from 239 to 600 mg/l.

3-1-9 Calcium and Magnesium ion:

Study results showed that the highest value for Ca⁺² was 260 mg/l in February at Station 2, while the lowest value was 65 mg/l in October at Station 1 (Fig. 3-11). The statistical analysis showed a significant difference among months for Ca⁺² at (P<0.05), but no any significant differences among stations was observed except with station2 (Table 3-1). The positive correlation with T.H and Mg⁺² (r= 0.521, and r= 0.034 respectively) (Table 3-2).

The results showed that there is an increase in calcium values during summer and winter, increase in summer due to the decrease of water levels and increase in evaporation in summer, also the dust storms that the CaCO₃ may be the major content of the dust particles in it caused the increase in Ca⁺² values (Wagnent et al., 2005; Sullivan et al., 2007), and the increase in winter might be due to the rain falls that bring salts including calcium
then increase of it concentration in water, also the stop of dredging operations occurred near the project intake exposed new layers of soil led to increase salts in water including calcium. Then the Ca\(^{+2}\) tended to decrease in autumn and spring due to the appropriate temperature, in which helped in dissolving of CO\(_2\) forming carbonic acid which help in dissolving the Ca\(^{+2}\) ions. This study similar to studies of Al-Nimrawee (2005), and Al-Fatlawy (2007) on Tigris River. The values of calcium in this study lower than the results of Nashaat (2010) 70-490 mg/l, and Abed Al-Razzaq (2011) 80-730 mg/l on Tigris River.

The highest value for Mg\(^{+2}\) was 104 mg/l in January at Station 2, while the lowest value was 10.9 mg/l in June at Station 4 (Fig. 3-12). The statistical analysis showed a significant differences among months for Mg\(^{+2}\) at (P<0.05), but no any significant differences among stations was observed except with station1 and 2 (Table, 3-1). The direct correlation with T.H, Ca, TSS, TDS, EC, DO., BOD and Salinity (r= 0.866, r= 0.034, r= 0.305, r= 0.545, r= 0.544, r= 0.260, r= 0.176 and r= 0.516 respectively) (Table, 3-2).

Ca\(^{+2}\) and Mg\(^{+2}\) ions decreased to low level during the spring season that might be due to the raise of water levels and to the growth of aquatic plants which lead to consumption of a lot of salts (Mahmood, 2008). Moreover, Kocet et al.,(2008) showed that the bio adsorption of Mg\(^{+2}\) ions by plants tend to be increase during spring season which lead to decrease the amount of Mg\(^{+2}\) as a result of consumption.

The results were similar to those of Nashaat (2010) on Tigris River, and Al-dehaimmy (2006) on Euphrates River. While the study results contrast with the results of Wahab (2010), Hashim (2010) and Abed Al-Razzaq (2011) on Tigris River.
The results showed the highest value for TDS was 1081 mg/l in November and September at Station-2, while the lowest value was 339 mg/l in June 2013 at Station-1 (Fig. 3-13). The statistical analysis showed a significant difference among months at (P<0.05), but no any significant differences among stations except station 1 and 2 (Table, 3-1). The direct correlation between TDS and Conductivity (r= 0.706) agree with (Al-Obaidi, 2009).

The present work showed that the high value in summer and autumn season as may be due to the increasing of dust storms and the increase in the rates of dry fallout into resources of surface water (Jain,2001), as well
as the increase salts concentrations especially calcium salts which increase TDS values (Goddard et al., 2009). These results agree with those of Al-Saadi et al., (1999) on Tigris and Euphrates River, Wahab (2010), Hashim (2010) on Tigris River.

3-1-11 Total Suspended Solids (TSS):

Present study findings showed the highest value for TSS was 2008 mg/l in February at Station 2, while the lowest value was 320 mg/l in August at Station 1 (Fig. 3-14). The statistical analysis showed a significant difference among months at (P<0.05), but no significant difference among stations except stations 1 and 2 (Table 3-1).

The TSS values were increased in winter and decreased in spring due to increase in water level, soil erosion and rainfall, as well as, other matters such as algae and organic matter. These results agree with Al-Lami et al. (1999) in Tigris river, which recorded that the TSS value ranged between 5 – 2465 mg/l, but higher than Al- Nimrawee (2005) which was found that
TSS value ranged from 10 to 235 mg/l and Al-Fatlawey (2007) that found the TSS value was ranged between 32.5- 848.3 mg/l in Tigris river. USEPA (2002) divided water in to three types depending on TSS value as: the concentration less than 20 mg/l as pure water, the water has values ranged from 20–80 mg/l as low turbidity water, values more than 150 mg/l as turbid water. According to TSS values recorded in the present study, it can be noted that Tigris river is turbid water.

3-1-12Nitrate (NO$_3^{-2}$):

Study results showed the highest value for NO3 was 70 mg/l in May in Station 2, while the lowest value was 0.5 mg/l in January in Station 1(Fig. 3-15). The statistical analysis revealed significant differences at (P<0.05) in NO$_3$ among months but no any significant differences among stations was observed except in station 2 (Table 3-1). The positive correlation between NO$_3$^{-2} and BOD$_5$ (r= 0.767) was observed in present study (Table 3-2).

The results agree with Abed Al-Razzaq (2011) with a range of between 0.58-49.5 mg/l in Tigris river, the values of NO$_3$ in some months is
higher the permissible limit for both Iraqi and WHO standards, which was 15 mg/l, station2 in May 2013 is higher the Iraqi river standard those receiving wastewaters, which was 50 (Table 1-4).

3-1-13 Chemical Oxygen Demand (COD):

The present study data showed that the highest value of COD was 710 mg/l in October at station2, while the lowest value was 31 mg/l in November at station1 (Fig. 3-16). The statistical analysis revealed a significant differences at (P<0.05) in COD among months and stations was observed (Table 3-1).

The COD results from station2 were higher than other stations (330-710) mg/l because the high discharge sewage, high organic matter in this site, which coincided with undetectable oxygen throughout several months during the studied period. These results agree with Shekha (2008) with a range 31.3 – 901mg/l on Greater Zab river, lower than Sarafraz (2007) with range 124.4 – 1560 mg /l on Iran hospital waste water, and lower than Emmanuel (2002) with range 604 - 2590 mg/l on France hospital waste water. The minimum values of COD is within the permissible limit for Iraqi
3-2 Heavy Metals (HMs):

3-2-1 Iron (Fe):

The maximum and minimum Iron levels for all samples were 0.9 - 0.014 mg/l. The maximum values were observed in February at station 2, while the minimum values were observed in November at station 4 (Fig. 3-17), Iron increased in winter months, and increase in all study period in station-2 because the hospitals waste water.

The statistical analysis of the data showed a significant differences among months at (P<0.05) but no such significant differences among stations except station 1 and 5 (Table 3-3). The direct correlation with Ni (r= 0.760) (Table 3-4). The Fe values within Iraqi and American river standards except in winter is higher those (Table 1-5).
Table (3-3): Minimum and maximum (First Line), mean and standard deviation (Second Line), for heavy metals studied (Fe, Cd, Pb, Ni and Zn) at study stations during 2012-2013.

<table>
<thead>
<tr>
<th>Stations</th>
<th>St.1</th>
<th>St.2</th>
<th>St.3</th>
<th>St.4</th>
<th>St.5</th>
</tr>
</thead>
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<tr>
<td>Heavy metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (mg/l)</td>
<td>0.02 – 0.19</td>
<td>0.06 – 0.9</td>
<td>0.06 – 0.5</td>
<td>0.014 – 0.29</td>
<td>0.03–0.09</td>
</tr>
<tr>
<td></td>
<td>0.08±0.001</td>
<td>0.29±0.003</td>
<td>0.15±0.002</td>
<td>0.09±0.002</td>
<td>0.075±0.002</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Cadmium (mg/l)</td>
<td>0.001-0.006</td>
<td>0.01 – 0.1</td>
<td>0.005 – 0.08</td>
<td>0.003 – 0.03</td>
<td>0.003 – 0.006</td>
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<td></td>
<td>0.0035 a</td>
<td>0.05</td>
<td>0.02</td>
<td>0.01</td>
<td>0.0045</td>
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<td>a</td>
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<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Lead (mg/l)</td>
<td>0.012–0.15</td>
<td>0.14 – 0.6</td>
<td>0.06 – 0.5</td>
<td>0.01 – 0.2</td>
<td>0.006 – 0.12</td>
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<td></td>
<td>0.05</td>
<td>0.27</td>
<td>0.18</td>
<td>0.06</td>
<td>0.044</td>
</tr>
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<td>c</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Nickel (mg/l)</td>
<td>0.004–0.13</td>
<td>0.01 – 0.4</td>
<td>0.04 – 0.11</td>
<td>0.02 – 0.09</td>
<td>0.005 – 0.05</td>
</tr>
<tr>
<td></td>
<td>0.03</td>
<td>0.14</td>
<td>0.06</td>
<td>0.04</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
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</tr>
</tbody>
</table>

Figure 3-17: Iron in Tigris river monthly variation during 2012/2013
Table (3-4): The correlation among some water parameters and heavy metals.

<table>
<thead>
<tr>
<th>Water Temp.</th>
<th>TSS</th>
<th>TH</th>
<th>NO3</th>
<th>Cl-</th>
<th>Fe</th>
<th>Pb</th>
<th>Cd</th>
<th>Ni</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>-0.560</td>
<td>0.476</td>
<td>0.102</td>
<td>-0.160</td>
<td>0.357</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>-0.619</td>
<td>0.574</td>
<td>0.604</td>
<td>-0.612</td>
<td>0.803</td>
<td>0.286</td>
<td></td>
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</tr>
<tr>
<td>Cd</td>
<td>0.346</td>
<td>-0.613</td>
<td>-0.070</td>
<td>0.166</td>
<td>-0.539</td>
<td>0.074</td>
<td>-0.490</td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>-0.393</td>
<td>0.421</td>
<td>-0.071</td>
<td>-0.232</td>
<td>0.356</td>
<td>0.760</td>
<td>0.261</td>
<td>-0.265</td>
</tr>
<tr>
<td>Zn</td>
<td>-0.008</td>
<td>0.233</td>
<td>-0.365</td>
<td>0.282</td>
<td>-0.058</td>
<td>0.015</td>
<td>-0.228</td>
<td>0.150</td>
</tr>
</tbody>
</table>

3-2-2 Cadmium (Cd):

The maximum and minimum cadmium levels for all samples were 0.1 - 0.001 mg/l, the maximum values were observed in September in station-2, while the minimum values were observed in November in station-1 (Fig. 3-18), The highest values were represented in the station-2, which may related to the Medical city hospital discharges. The statistical analysis of the data showed no significant differences among months and stations at (P<0.05) (Table 3-3).

The cadmium concentration was not affected by the seasonal or climatic changes because the major source of cadmium contamination is the corrosion of transferring pipes made of cadmium as well as the wastewater involving cadmium into the river without processing (Machemer and...
Wildman, 1992). The Cd values is higher the Iraqi, WHO and American standards (Table 1-5).

3-2-3 Lead (Pb):

The maximum and minimum lead levels for all samples were 0.6 - 0.01 mg/l. The maximum values were observed in January at station 2, while the minimum values of Pb were reported in March at station 4 (Fig. 3-19), lead increased in winter months. The statistical analysis of the data showed significant differences among months at (P<0.05) and significant differences among stations except between station 2 and 3 (Table 3-3).

The lead concentrations during winter were higher than spring and summer. The lead concentration increased due to the Cars exhausts because the cars fuel contain Tetra ethyl lead and Tetra methyl lead As enhancers of fuel, then the rains work on washing them to the rivers (Akoto et al., 2008; Yazdi & Behzad, 2009).

Generally, the values of pb for stations 2 and 3 exceeding the permissible limit for Iraqi river standards, and in other stations within in some months (Table, 1-5).
3-24 Nickel (Ni):

The maximum and minimum nickel levels for all samples were 0.4 - 0.004 mg/l. The maximum values were reported in December in station 2, and the minimum values were observed in October in station 1 (Fig. 3-20). The statistical analysis revealed significant differences at (P<0.05) in Ni among months but no any significant differences among stations (Table 3-3).

May be due to the weak capacity of nickel to form stable complexes in combination with organic material in the water, which may help to reduce the nickel concentrations in the water (Hart, 1981).

The Ni values are within Iraqi river standard, except station 2 in December is higher, and in mostly months is higher WHO values (Table 1-5).
3-2-5 Zinc (Zn):

The maximum and maximum zinc levels for all samples were 0.22 - 0.004 mg/l. The maximum values were reported in April in station 2, while the minimum values were observed in August in station 1 (Fig. 3-21). The statistical analysis revealed no significant differences among months and stations (Table 3-3).

The pollution sources with zinc is not linked to climate, pollution with zinc come from the disposal of untreated water containing zinc via throw it in the river or water bodies in general (Martin et al., 2007; Babel and Dacera, 2006).

The Zn concentration for all selected sites in the Tigris river within the permissible range of values reported by the Iraqi, WHO and American Standards river water (Table 1-5). While the maximum concentration of Zn was above the USEPA (2007) recommended maximum values 0.015 mg/l.
3-3 Microbial properties:

3-3-1 Total bacterial count (T.B.C):

This group represents mostly bacteria entering the water from sewage and types of bacteria that drift with soil to water during the seasons of rains and floods (Allochthonous), as well as the original bacteria in water (Autochthonous) (Al-Fatlawy, 2007). Figure (3-22) shows monthly changes in T.B.C for the four selected stations, values ranged between 10000 cell/1ml in station 1 during April to 2700000 cell/1ml in station 2 during March. The statistical analysis revealed significant differences at \( P<0.05 \) in T.B.C among months and stations. (Table 3-5).

The highest number found in station 2 in all study period, where hospital sewage discharge, and increase in February and March, then decrease and retrained increase in July, August and September, these differences may be associated with patient’s number in hospitals from months to other.
Table (3-5): Minimum and maximum (First Line), mean and standard deviation (Second Line), for Bacteriological characteristics at study stations during 2012-2013.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Stations</th>
<th>St.1</th>
<th>St.2</th>
<th>St.3</th>
<th>St.4</th>
<th>St.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Bacterial</td>
<td></td>
<td>10000–400000</td>
<td>300000–2700000</td>
<td>100000–2200000</td>
<td>100000–1130000</td>
<td>300000 – 900000</td>
</tr>
<tr>
<td>Count cell/1ml</td>
<td></td>
<td>174166.7±48.1</td>
<td>1241667±40.3</td>
<td>908333.3±62.9</td>
<td>452500±29.4</td>
<td>500000±33.7</td>
</tr>
<tr>
<td>Total Coliform</td>
<td></td>
<td>200–2400</td>
<td>680–3700</td>
<td>400–2800</td>
<td>200–1700</td>
<td>45–240</td>
</tr>
<tr>
<td>cell/100ml</td>
<td></td>
<td>c</td>
<td>a</td>
<td>b</td>
<td>d</td>
<td>c</td>
</tr>
<tr>
<td>Faecal Coliform</td>
<td></td>
<td>100 – 930</td>
<td>200–2400</td>
<td>180 – 1100</td>
<td>100 – 610</td>
<td>20 – 68</td>
</tr>
<tr>
<td>cell/100ml</td>
<td></td>
<td>c</td>
<td>a</td>
<td>b</td>
<td>d</td>
<td>e</td>
</tr>
<tr>
<td>cell/100</td>
<td></td>
<td>d</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>e</td>
</tr>
<tr>
<td>Faecal Streptococcus</td>
<td></td>
<td>0 ± 0</td>
<td>180 – 920</td>
<td>180 – 400</td>
<td>180 – 200</td>
<td>20 – 40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d</td>
<td>460±17.5</td>
<td>213.3±8.3</td>
<td>190±8.1</td>
<td>26.66±1.9</td>
</tr>
</tbody>
</table>
3-3-2 Total Coliform (TC):

Coliform bacteria had been used historically to assess the microbial quality of drinking water, also no consider as indicators of faecal contamination, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms. Some Coliform bacteria may be part of the natural bacterial flora in water and intestines of human and warm-blooded animals. Coliforms are also considered useful for monitoring treatment processes and assessing the disinfection of new or repaired mains (WHO, 2003).

The figure (3-23) shows monthly changes in TC values which ranged between 200 cell/100ml in January, May and June in station1, and in January, March and July in station4 to 3700 cell/100 ml in station2 during April. The statistical analysis revealed significant differences at (P<0.05) in TC between months and stations (Table 3-5).

Hot months are associated with increased TC because of temperature, human and microorganism activities increased (Waite, 1980). The highest number appears in station 2 in all study period, where hospital sewage discharges, organic and inorganic nutrient increased.

Result similar to Ibrahim et al., (2013) was 1600 cell/100ml in Tigris river, but lower than Mayaly (2000) which was 230600 cell/100ml. This study showed that the minimum TC is allowable but not desirable concentration, were the maximum TC is higher concentration, not allowable (Table 1-6).
3-3-3 Faecal Coliform (FC):

The FC is associated with this bacteria in gut, because of their largest number, longer survive in water and easy in detection and considered as evidence of the presence of intestinal pathogenic bacteria in the water, although detection of FC is use in all global laboratories for water pollution detection and suitability for drinking uses but it should be noted that it does not have to be sourced from the human intestine is also present in the intestines of warm-blooded animals (Edberg, 2000). FC has been shown to represent 93% - 99% of Coliform bacteria in faeses from humans, poultry, cats, dogs and rodents (WRC, 2003). FC is considered as an indicator for recent microbial pollution (Al-Jebouri, 1981).

The figure (3-24) shows monthly changes in FC, the lowest 100 cell/100 ml was encountered in Station-1 during November 2012 and February 2013 and the highest 2400 cell/100 ml was recorded in station-2 during May 2013 can be attributed to suitable environmental conditions for bacteria growth in this season and also returned to hospital and domestic waste waters and indiscriminate defecation along the river banks by both humans and other animals that graze along the river banks (Al-Fatlawy, 2007).
The statistical analysis revealed significant differences at \((P<0.05)\) in F.C between months and between stations too (Table 3-5). Study result above Ibrahim et al., (2013) which was 863 cell/100 ml, this study showed that the means of FC was allowable but not desirable (Table 1-6).

![Figure 3-24: Faecal Coliform monthly variation in Tigris river during 2012/2013](image)

3-3-4 Total Streptococci (TS):

The lowest 200 cell/100 ml of TS was measured in station1 during October, November, December 2012 and from March to September 2013, and in station-3 during March, April, May, June and September 2013, and in station-4 during March, April, May, June, October and September, to the highest 2800 cell/100 ml was observed in January 2013 in stations 2, 3, 4 and in February 2013 in station-2, because humans and animals activity (Fig. 3-25). The statistical analysis showed a significant differences among months at \((P<0.05)\) and significant differences among stations (Table 3-5).

Tigris river varies considerably concentration because of self-purification mechanism, good mixing, and larger water volume. The increase in numbers of TS during winter especially at station 2 and 3, May be due to the organic matter which enters
in large quantities of station 2 and low water temperature which act on survival of the bacteria for longer period (Atlas et al., 1996). This study showed that the means of TS was allowable but not desirable, and the maximum values are not allowable (Table 1-6).

![Total Streptococci monthly variation in Tigris river during 2012/2013](image)

### 3-3-5 Faecal Streptococci (FS):

The Faecal Streptococcus is intestinal bacteria, have been used as indicators of fecal contamination in water because their presence in the intestines of humans and animals, as well as its presence in the soil and on plants and some insects (APHA, 2005). There are several studies demonstrated that faecal streptococci have been considered to be useful indicators of faecal contamination of water resources (Mwakalobo et al., 2013).

Monthly changes were explain in figure (3-26) in FS the lowest is Nil was observed in station-1 during the all study time, to the highest 920 cell/100 ml measured from station-2 in October. In station-1 there are no factory, no discharge and no humans or animals activity so it’s Nil, and the highest in station-2 in January because the hospital discharge and their bacterial activity. The statistical analysis revealed significant differences at (P<0.05) in FS between both months and stations (Table 3-5). The results agree with Al-Rahbi (2002) on Al-Habania &
Al-Tharthar reservoirs was 600 cell/100 ml. This study showed that the FS was allowable but not desirable except station 1 which is desirable (Table 1-6).

![Faecal Streptococci monthly variation in Tigris river during 2012/2013](image)

**Figure 3-26: Faecal Streptococci monthly variation in Tigris river during 2012/2013**

### 3-3-6 FC: FS Ratio:

Table (3-6) shows the lowest value for this ratio is (0) in Station 1 in all study time, and the highest is (8) in May Station 2. Station 1 is animal source, there are no factory, no human activities, and station 4 in April and May is animal source because hospital sewage diluted with river and reduces after this away. In station 2, 3 is humans source because hospital sewage, also in station 4 in all study time except April and May.

<table>
<thead>
<tr>
<th>FC/FS</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct.</td>
<td>0</td>
<td>1.5</td>
<td>1.12</td>
<td>1</td>
</tr>
<tr>
<td>Nov.</td>
<td>0</td>
<td>1.7</td>
<td>2</td>
<td>1.1</td>
</tr>
<tr>
<td>Dec.</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Jan.</td>
<td>0</td>
<td>1.12</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Feb.</td>
<td>0</td>
<td>1.11</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>March</td>
<td>0</td>
<td>6.6</td>
<td>6</td>
<td>1.1</td>
</tr>
<tr>
<td>April</td>
<td>0</td>
<td>3.5</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>May</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>June</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3.3</td>
</tr>
</tbody>
</table>
July | 0 | 4 | 1 | 1  
August | 0 | 3.5 | 2.25 | 1  
Sept. | 0 | 2 | 2 | 1.1  

### 3-3-7 Diagnosis:

Table (3-7): Bacteria genera and species isolated from four stations selected by API System.

<table>
<thead>
<tr>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E.Coli</em></td>
<td><em>E.Coli,</em></td>
<td><em>E.Coli,</em></td>
<td><em>E.Coli</em></td>
</tr>
<tr>
<td><em>Onchrobactriumauthropi</em></td>
<td><em>Onchrobactriumauthropi</em></td>
<td><em>Onchrobactriumauthropi</em></td>
<td><em>Onchrobactriumauthropi</em></td>
</tr>
<tr>
<td>Panteoa</td>
<td>Panteoa</td>
<td>Panteoa</td>
<td>Panteoa</td>
</tr>
<tr>
<td><em>Bacillus cereus</em></td>
<td><em>Bacillus cereus</em></td>
<td><em>Bacillus cereus</em></td>
<td><em>Bacillus cereus</em></td>
</tr>
<tr>
<td>Sarcina maxima</td>
<td>Sarcina maxima</td>
<td>Sarcina maxima</td>
<td>Sarcina maxima</td>
</tr>
<tr>
<td><em>Burkholderiacepia</em></td>
<td><em>Staph</em>(Micrococcus spp)</td>
<td><em>Burkholderiacepia</em></td>
<td><em>Burkholderiacepia,</em></td>
</tr>
<tr>
<td>Klebselliaoxytoca</td>
<td><em>Enterobacteraerogenes</em></td>
<td>Staph.hominis</td>
<td><em>Klebsiella pneumonia</em></td>
</tr>
<tr>
<td><em>Enterobacteraerogenes</em></td>
<td><em>Klebsiella pneumonia</em></td>
<td>Staph.hominis</td>
<td><em>Pseudomonsaeruginosa</em></td>
</tr>
<tr>
<td><em>Pseudomonsaeruginosa</em></td>
<td><em>Pseudomonsaeruginosa</em></td>
<td><em>Klebsiella pneumonia</em></td>
<td><em>Pseudomonsaeruginosa</em></td>
</tr>
<tr>
<td></td>
<td><em>Salmonella typhi</em></td>
<td><em>Pseudomonsaeruginosa</em></td>
<td><em>Salmonella typhi</em></td>
</tr>
</tbody>
</table>

The results of bacterial isolates and diagnosis from the water during this study agree with Humudat (2009) and Al-Jubouri (2005), who found that the maintain isolates in water samples are mostly negative to Gram stain. The maintains of negative gram stains may be due to the possession of the outer membrane, which works to protect bacteria G-ve from the external effects (Al-Wa'ilì, 2008).
3-4 The fifth station (Al-Wathba water intake):

Al-Wathba water intake located between station-1 (The control) and station-2 (Medical city hospital discharge), and to be sure from results and pollution source, take seasonally samples from it.

Results of this station when comparing with station 1 (the control) shows a significant differences with Turbidity, Total Dissolved Solid, Total Hardness, Magnesium, Chemical Oxygen Demand, and bacteriology tests except Fecal Streptococcus at (P<0.05) (Table 3-1, 3-3 and 3-5).
Conclusions:-

1) The results revealed that the most examined water parameters were more than Iraqi, and WHO standards for the water river.

2) The waste water of Medical City hospitals in Baghdad affects the characteristics of Tigris river water.

3) High organic materials in water discharge appear by (COD) parameter, this is due to the higher use of chemical compounds, solution and sterilizers.

4) Results showed that the Fe, Ni and Zn within permissible limit, while pb and Cd exceeding permissible limit for Iraqi and WHO standards for river system maintains.

5) The values of biological factors are not allowable in river.

6) Al-Wathba water intake station effect on the biological and some physicochemical characteristic of Tigris river.

Recommendation:-

1) The authorities should have a monitoring programme to maintain the Tigris river without pollution.

2) Finding a local treatment unit for liquid waste treatment proposed by the hospitals and in accordance with the environmental requirements.

3) Examining the solids medical waste, and disposal methods and the impacts on the surrounding environment.

4) Reformulation of enacting laws - regarding punish violators of factories and facilities that pose a direct waste - and entering it into effect.
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Geographical Information System, Water Quality

**Expo Health, 2, 193-203.**


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o (V)


## Appendix 1: Medical City Hospitals survey

<table>
<thead>
<tr>
<th>Hospital Name</th>
<th>Year</th>
<th>Beds no.</th>
<th>Inpatients daily</th>
<th>Outpatients daily</th>
<th>Operation daily</th>
<th>Staff No.</th>
<th>Space (M²)</th>
<th>Floor No.</th>
<th>Outpatient clinic</th>
<th>Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Nursing Home Hospital</td>
<td>1982</td>
<td>349</td>
<td>30</td>
<td>8</td>
<td>11</td>
<td>443</td>
<td>5000</td>
<td>7</td>
<td>Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>Baghdad Teaching Hospital</td>
<td>1970</td>
<td>1000</td>
<td>75</td>
<td>900</td>
<td>47</td>
<td>2371</td>
<td>83190</td>
<td>11</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>Specialized Burn Hospital</td>
<td>2010</td>
<td>47</td>
<td>5-15</td>
<td>10</td>
<td>5-8</td>
<td>238</td>
<td>6500</td>
<td>2</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>Child Protection Teaching Hospital</td>
<td>1983</td>
<td>200</td>
<td>30</td>
<td>90</td>
<td>6</td>
<td>560</td>
<td>6552</td>
<td>4</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>Kazy Al-Harery Surgical Specialties Hospital</td>
<td>1980</td>
<td>672</td>
<td>50</td>
<td>255</td>
<td>24</td>
<td>1200</td>
<td>6440</td>
<td>16</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>Gastroenterology &amp; Herpetology center.</td>
<td>1994</td>
<td>85</td>
<td>305</td>
<td>-------</td>
<td>2</td>
<td>230</td>
<td>4000</td>
<td>1</td>
<td>Not Available</td>
<td>Available</td>
</tr>
</tbody>
</table>
Appendix 2: Fig. a, b and c Represent station-2.
Appendix 3: Fig. represents Al-Wathba water intake station.

Appendix 4: API 20E System

API 20E is an identification system for the Enterobacteriaceae. This test applied according to the supplied company (Bio-Merieux) instructions as following:

**Inoculums preparation:**

Checking the purity of tested bacteria, isolates with 18-24 hours growth were transferred to API 20E Medium, mixed well to prepare a homogenous bacterial suspension with a turbidity equivalent to 0.5 McFarland standards.

**Strip preparation:**

An incubation box was prepared by distribution of 5ml distilled water to wells of tray to create a humid atmosphere. Then the strip was removed from its packaging and placed in the incubation box.

**Strip inoculation:**
By using a micropipette, the microtubes were filled with inoculated medium; the tip of the pipette was placed against the side of the cupule (upper part) to avoid bubbles formation at the base of the tube. Filling only the lower part (tube), with the exception of the two tests of arginine hydrolysis and urease production (ADH, URE) which the lower part filled with bacterial inoculums and the cupules filled with mineral oil. Then the incubation box was closed by the lid and incubated at 37\(^{\circ}\)C for 18-24 hours.

**Reading the strip:**

The strip is read after inoculation and incubation at 37\(^{\circ}\)C for 18-24 hrs. By noting color changes after the various indicator or added reagents. The identification of the unknown bacteria is achieved by determining a seven digits profile index number and consulting the Api 20E profile index booklet (Rump, 1999).

<table>
<thead>
<tr>
<th>Test</th>
<th>Abbreviations</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-galactosidase</td>
<td>ONPG</td>
<td>Colorless</td>
</tr>
<tr>
<td>Arginine dehydrolyase</td>
<td>ADH</td>
<td>Yellow</td>
</tr>
<tr>
<td>Lysine decarboxylase</td>
<td>LDC</td>
<td>Yellow</td>
</tr>
<tr>
<td>Ornithine decarboxylase</td>
<td>ODC</td>
<td>Yellow</td>
</tr>
<tr>
<td>Citrate Utilization</td>
<td>CIT</td>
<td>Pale green</td>
</tr>
<tr>
<td>H2S Production</td>
<td>H2S</td>
<td>Colorless</td>
</tr>
<tr>
<td>Urease</td>
<td>URE</td>
<td>Yellow</td>
</tr>
<tr>
<td>Tryptophan deaminase</td>
<td>TDA</td>
<td>Yellow</td>
</tr>
<tr>
<td>Indol Production</td>
<td>IND</td>
<td>Green ring</td>
</tr>
<tr>
<td>Voges Proskauer</td>
<td>VP</td>
<td>Colorless</td>
</tr>
<tr>
<td>Gelatinase</td>
<td>GEL</td>
<td>Dye not spread</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----</td>
<td>---------------------</td>
</tr>
<tr>
<td>Glucos Fermentation</td>
<td>GLU</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Mamnitol Fermentation</td>
<td>MAN</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Inositol Fermentation</td>
<td>INO</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Sorbitol Fermentation</td>
<td>SOR</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Rhamnose Fermentation</td>
<td>RHA</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Sucrose FERMINTATION</td>
<td>SAC</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Melebiose Fermentation</td>
<td>MEL</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Amygdaline Fermentation</td>
<td>AMY</td>
<td>Blue-greenish blue</td>
</tr>
<tr>
<td>Arabinose Fermentation</td>
<td>ARA</td>
<td>Blue-greenish blue</td>
</tr>
</tbody>
</table>

**Appendix 5: API Staph System**

API Staph. is an identification system for the genera *Staphylococcus* and *Micrococcus*. This test applied according to the supplied company (Bio-Merieux) instructions as following:

**Inoculums preparation:**

After checking the purity of tested bacteria, isolates with 18-24 hours growth were transferred to API Staph. Medium, mixed well to prepare a homogenous bacterial suspension with a turbidity equivalent to 0.5 McFarland standards.

**Strip preparation:**

An incubation box was prepared by distribution of 5ml distilled water to wells of tray to create a humid atmosphere. Then the strip was removed from its packaging and placed in the incubation box.

**Strip inoculation:**
By using a micropipette, the microtubes were filled with inoculated medium; the tip of the pipette was placed against the side of the cupule (upper part) to avoid bubbles formation at the base of the tube. Filling only the lower part (tube), with the exception of the two tests of arginine hydrolysis and urease production (ADH, URE) which the lower part filled with bacterial inoculums and the cupules filled with mineral oil. Then the incubation box was closed by the lid and incubated at 37°C for 18-24 hours.

**Reading the strip:**

After the incubation period, the results were read by referring to the reading table, with the addition of the following reagents:

- VP test: one drop of each VP1 and VP2.
- NIT test: one drop of each NIT1 and NIT2.
- PAL test: one drop of each ZYM A and ZYM B.

The results of these three tests were read after 10 minutes according to the reading table. The results were read according to the manufacture company guidance by recording the results (+ or -), then these results converted to numbers, the strip was divided to seven groups, each group contained three tests which numbering with (1,2,4), each positive test gave its own number which was recorded on the results sheet while the negative test was given (0). Then the summation of these three numbers were measured and they were limited between (0-7), finally the code number consisting of seven numbers was obtained and interpreted with the numbers of an Analytical Profile Index supplied by the manufacture company to identify the genus and species of the tested bacteria.
<table>
<thead>
<tr>
<th>Test</th>
<th>Symbol</th>
<th>Negative result</th>
<th>Positive result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative control</td>
<td>0</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of D-Glucose</td>
<td>GLU</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of D-Fructose</td>
<td>FRU</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of D-Mannose</td>
<td>MNE</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of Maltose</td>
<td>MAL</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of Lactose</td>
<td>LAC</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of D-Trehalose</td>
<td>TRE</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of D-Mannitol</td>
<td>MAN</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of Xylitol</td>
<td>XLT</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of D-Melibiose</td>
<td>MEL</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Reduction of nitrate to nitrite</td>
<td>NIT</td>
<td>Colorless-light pink</td>
<td>Red</td>
</tr>
<tr>
<td>Alkaline phosphatase</td>
<td>PAL</td>
<td>Yellow</td>
<td>Violet</td>
</tr>
<tr>
<td>Acetyl-methyl-carbinol production</td>
<td>VP</td>
<td>Colorless</td>
<td>Violet-pink</td>
</tr>
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<td>Acidification of Raffinose</td>
<td>RAF</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of Xylose</td>
<td>XYL</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acidification of Sucrose</td>
<td>SAC</td>
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</tr>
<tr>
<td>Acidification of α-methyl-D-glucoside</td>
<td>MDG</td>
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</tr>
<tr>
<td>Acidification of N-acetyl-glucosamine</td>
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</tr>
<tr>
<td>Arginine dihydrolase</td>
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<td>Orange-red</td>
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<tr>
<td>Urease</td>
<td>URE</td>
<td>Yellow</td>
<td>Red-violet</td>
</tr>
</tbody>
</table>
Appendix 6: Bacillus Diagnosis

After culture on Nutrient agar, stained by a gram stain and diagnosis by Microscope.

Fig. a: Bacillus cereus on Nutrient agar.

Fig. b: Bacillus cereus on Microscope.
الخلاصة:

دُرَّست التغييرات الشهرية للخصائص الفيزيائية والكيميائية والبكتريولوجية للمياه لتقسيم نوعية مياه نهر دجلة وقياس تأثير ملوثات مستشفى مدينة الطب على النهر للعدة من شرين الأول 2012 إلى أيلول 2013. قُبِّل مجمع مدينة الطب في بغداد، في الجانب الشرقي من نهر دجلة (الرصافة) تمتد بين جسر الصرافية و جسر باب المعظم. اختُبرت أربع مصاطب للدراسة، تقع المحطة الأولى قبل مجمع مدينة الطب ب 500 متر. إذا تمثل محطة السيطرة، أما المحطة الثانية فهي تصرف ملوثات مدينة الطب إلى النهر. تقع المحطة الثالثة على بعد 500 متر من المحطة الثانية، أما المحلة الرابعة فتقع على بعد 2000 متر من المحلة الثالثة. أما محلة ساحة الوثبة التي تقع قبل المحلة الثانية ب0.7 متر فقد تم اعتبارها المحلة الخامسة لتأكيد من مصدر التلوث.

أخذت العينات شهرياً ويعقوب نموذجين لكل شهر من المحطات الأربعة وموسمياً من محطة أسدية الوثبة، على عمق (10 - 20) سم من سطح الماء تقريباً. أُشطرت نتائج الدراسة ارتفاع تراكم وقيم التوصيفية الكهربية، والملوحة، والعكورة، والمتطلب الحيوي للأوكسجين، والمتطلب الكيميائي للأوكسجين، والأوكسيدات، والعصرة الكلية، والكالسيوم، والمغنيسيوم، والمواد ذاتية الكلية، والمواد العالية الكهربية، والنتريت، والمعادن الثقيلة (الحديد، والكالسيوم، والرصاص، والنيكل، والزنك). والأعداد الكلية للكيبريا، وأعداد بكتيريا القولون، والقولون البرازية وبكتيريا المسببات، والسمسحيات البرازية في المحطة الثانية عن بقية المحطات في اغلب الأشهر. وأظهرت انخفاض قيم الأكسيدوجين، والأوكسجين المذابفي المحطة الثانية.

تراوحت قيم درجات حرارة الهواء والماء بين (12 - 32 و11-2) م. على التوالي، وقيم العكورة كانت بين (0.4 - 250) نفاثين وحدة كاميرا. أما قيم التوصيفية الكهربية كانت بين (400-320) مليكر/سبيمانز. وقيمة الملمحة تراوحت بين (1.50-1.00) أوم. أما قيم المواد ذاتية الكلية، والملزوجات بين (300-1000) ملغم/لتر. وقيمة المواد العالية الكلية كانت بين (300-1000) ملغم/لتر. إن مياه نهر دجلة كانت قاعدية حيث سجلت قيم الأس الهيدروجيني بين (6.2-9.1) وكانت ذات تهوية جيدة إذ أن قيم الأوكسجين كانت عالية في أشهر الشتاء مسيرة تغييراً شهرياً واضحًا إذ تراوحت بين (3-5) ملغم/لتر، وارتفاعت قيم المتطلب الحيوي للأوكسجين في بعض المحطات وقد كانت قيمها بين (0.5-6) ملغم/لتر، أما المتطلب الكيميائي للأوكسجين فقد كانت قيمته بين (31-710) ملغم/لتر. وجد أن مياه النهر عسرة جداً إذ أن قيم العسرة الكلية قد تراوحت بين (170-425) ملغم/لتر. وقيمة الكالسيوم تراوحت بين (5-200) ملغم/لتر. وقيمة المغنيسيوم تراوحت بين (9-160) ملغم/لتر. أما قيم النترات فقد تراوحت بين (50-190) ملغم/لتر. وقيمة النترات فكانت (50-70).
القيم العليا من النتائج تجاوز الحد المسموح به للمواصفات العراقية ومنظمة الصحة العالمية ل sistm مادة الأملاح.

أما بالنسبة لقيم المعادن الثقيلة فتراوح قيم الحديد بين (0.04 - 0.14) ملغم/لتر، وقيم الكادميوم بين (0.01 - 0.03) ملغم/لتر، وقيم الرصاص (0.01 - 0.03) ملغم/لتر، وقيم الزنك بين (0.04 - 0.06) ملغم/لتر، وقيم النيكول كانت بين (2.04 - 4.040) ملغم/لتر. أظهرت معدلات تراكيز هذه المعادن تغيرات شهرية في نهر دجله خلال فترة الدراسة حيث كان الحديد والنيكل والزنك ضمن الحدود المسموح بها، بينما الرصاص والكادميوم تجاوز الحد المسموح به للمواصفات العراقية ومنظمة الصحة العالمية ل sistم مادة الأملاح.

أما بالنسبة لدراسة الأملاح الآلية فتراوح قيم الحديد الكلي للكترييا الهوائية (2000 - 3700 خلية/مل)، بينما تراوحت أعداد بكتيريا القولون والقولون البرازية بين (200 - 400) خلية/مل على التنايل. أما بالنسبة لأعداد بكتيريا المسبحيات والمسبحيات البرازية فتراوحت بين (200 - 400) خلية/مل على التنايل. أظهرت معدلات القيم في هذه الدراسة نتائج مقبولة ولكن غير مرغوب بها. أما القيمة العليا فقد كانت غير مسموح بها.

أما محطة أسامة الوثبة عند مقارنتها مع المحطة الأولى (محطة السيطرة)، كانت ذات فروقات معنوية بالنسبة للعكورة، وقيم المواد الغذائية الكلية، والعسرة الكلية، وقيم المغنيسيوم، والمتبقي الكيميائي للأوكسجين، والفحوصات البكتريكولوجية ماعدا المسببات البرازية.
تقييم تأثيرات مياه الفضلة الصحية لمدينة بغداد الطبية في نوعية مياه نهر دجلة

رسالة مقدمة إلى

مجلس كلية العلوم - جامعة بغداد

وهي جزء من متطلبات نيل درجة الماجستير في علوم الحياة - علم البيئة

تقدمت بها

ورقاء نوفيل معله
بكالوريوس علوم حياة - جامعة بغداد - 2011

بإشراف

أ.د. محمد نافع علي العزاوي

١٤٣٥ ٢٠١٣