Chapter Two

THEORY AND LITERATURE REVIEW

2.1 General:

Rotten-egg smells, red brown stains on plumbing fixtures, bathtub rings- all these are unpleasant signs of water quality problems, but usually not of harmful contaminants in the water. Contaminants that may threaten our health are usually not discernible by the senses. Drinking water can contain nitrate, bacteria, solids and pesticides at level which cannot be tested or smelled but which can be hazardous to health. Solids are found in streams in two forms, suspended and dissolved. Suspended solids are include silt, stirred-up bottom sediment, decaying plant matter, or sewage-treatment effluent while dissolved solids in fresh water samples include soluble salts that yield ions such as sodium, calcium…etc. Suspended solids will not pass through a filter, whereas dissolved solids will.

2.2 Tigris River:

The water samples examined in the study are taken from apart of Tigris River inside Baghdad. The Tigris River is one of the largest rivers of the Middle East. Its Length is 1900 km and 1415 km of them run within the Iraqi area.

The Main catchment's of Tigris River area is a mountainous part of its Basin within Turkey, where the river takes its main tributaries- the Batman,Garzan, and Bohtanchar rivers. The river emerges from the

South-west Turkey, from the confluence of small water courses Paginating the Geldjuk Lake at the altitude of about 1200 m above Sea level. When the Tigris River leaves the river bekir skya plain, three large Tributaries, the Batman, Garzan, and Bkhtan- Char Rivers join the Tigris River. These three tributaries from the most flow of the Tigris River in The upper pool. The Khabour River, 6270 km2 catchment area joins the Tigris River at the Iraqi- Turkish boundary downstream, the Tigris River takes additional feeding on the account of left bank tributaries the upper - Zab, the lower- Zab, Diyala River and the Adhaim River.

Downstream Mosul the river usually widens greatly, there at the 245 Km, from Turkish boundary the upper- Zab which considered a one of the Largest tributaries joins Tigris River, at the 369 km the lower- Zab River, the second largest tributary, falls into the Tigris River. These tributaries form the most of the flood water.

Near Fat’ha the river cuts through the last natural obstacle on its Way the Makhul- Hamrin mountain ridge- after that it traverses the Mesopotamia lowland up to the out fall receiving two more considerable Tributaries- the Adhaim River which joins the Tigris River at the 828 km From the outfall (68 km downstream Samara’a), and the Diyala river at The 683 km (30 km downstream the Baghdad- Sarai gauge site).

Downstream, after Samara’a Bridge and regulator as well as the Tigris- tharthar tail escapes were put into action, natural regime of the Tigris River is completely disordered.

From Kut, where the barrage was constructed, the river runs through the poorly populated swamp area the area of the lift side is occupied by the marshes which are fed, mainly, by the rivers flowing from the Iranian area, or by flood water intensive escape from the main river- bed through outlets in the levees as well as water delivered due to tail escapes from the musharra, Kyahla, and Micheriya canals.

Water from the marshes feeds the Tigris River through the Kassarah And Rota channels joining the Tigris River at the 59 km and 23 km Correspondingly upstream of Al-Qurna.

Starting from 1965 a part of flood flow of the Tigris River is diverted in the Tharthar reservoir (discharge escape made up about 120 km^3 of water for the period 1965-1978) resulting in considerable changes Changes observed in the Tigris river flow downstream of the Samara barrage.

Operation of the barrage near the town of Samara was designed in Conformity with necessity to limit the discharge capacity of the river-bed At the downstream area in order to protect the city of Baghdad from Inundation.

Downstream near Kut, where the barrage was constructed in 1939, The Garraf canal, the largest in Iraq, runs away from the Tigris River. This Canal flows along the Shat-Al-Arab old river-bed. Downstream of the Barrage, the main part of the flow is discharge along the Musanduk, Butaira, Musharra, Kahla, and Major Al- Kebir canals into the Qurna and Huwaiza marshes. In the zone of Tigris flow forming the annual sum of precipitations reach 800- 1500 mm. In accordance with the character of feeding and distribution of precipitations, one can distinguish three periods in the annual cycle of the Tigris River water regime: flood period (February- June) connected with snow thawing in the mountains, summer low water period (July- October) and a period of rain flooding (November- February) within the flood period the Tigris river conveys About 75% of annual flow, in the dry period about 10% and in the period Of autumn- winter floods about 15%. [1]

2.3 Tests:

The tests which have been examined in this study were total solids, suspended solids and dissolved solids.

2.3.1 Total solids (TS):

"Total solids" may be define as the term applied to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a define temperature. Total solids include "total suspended solids" the portion of total solids retained by a filter and "total dissolved solids" the portion that passes through the filter.

TS represent the total of all solids in a water samples. Total solids are the sum of the Total Suspended Solids and the Total Dissolved Solids. Total solids can be measured by evaporating a vessel contain a defined volume of sample at a defined temperature. Total solids are the solids which can be removed from the wastewater by physical or mechanical means, such as sedimentation or filtration. More precisely, they are the solids in a sample which are retained on a filter. While total solids in and of itself is not a "regulated parameter", raising this limit dose have a direct effect on the total dissolved solids that can be discharged into the system. Since total suspended solids are currently limited to 300mg/L, total dissolved solids are limited to a maximum of 2000 to 1700 mg/L depending on the amount of TSS in the sample (TS=TDS+TSS). Therefore, if the total solids limit is raised to the proposed 4000 mg/L, the concentration of TDS possible will, in effect, be raised to a maximum of 4000 to 3700 mg/Lt of, again depending on the amount of TSS in the sample [2].

Sensitive hydrometer would afford a method of estimating total solids in irrigation waters and soil extracts. The hydrometer is the simplest of all methods for measuring density of liquids, but it is by no means the most accurate, for, since the water surface does not provide a sharp line of reference, an appreciable error in the readings might be easily made.[3]

2.3.2 Suspended solids (TSS):

These are insoluble solids particles that either float on the water surface or are in suspension, TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentration of suspended solids can cause many problems for stream health and aquatic life.

There are various opinions on whether the level of TSS currently reported by most storm water studies other than from severe soil erosion impact beneficial water uses. TSS is a frequently reported parameter as a surrogate for other storm water pollutant including metals, nutrients and various organics. Acute fish toxicity tests have found that most species can endure exposure of more than 100,000 mg/l TSS for a week or longer. These TSS levels are almost 1000 times the levels found in storm water runoff from urbanized areas. The center for streamside studies, 1991 reported that TSS at concentration of 300-400 mg/l may reduce visibility of fish and impair their search for food and that sustained high concentrations of suspended sediment could reduce primary production if other factors are not limiting. [4]

Lloyd (1987) suggested that high levels of suspended solids may be fatal to salmonids, while lower levels of SS and turbidity may cause chronic sub lethal effects such as loss or reduction of foraging capability, reduced growth, resistance to disease, increased stress, and interference with cues necessary for orientation in homing and migration.[5]

The suspended solids in the Yukon River originate from the glaciers that feed its tributaries. The suspended solids in glacier- fed streams are formed from rocks and boulders that have been fractured and ground up by the glacier's movement. These particles range in size from stones and pebbles to a very fine powder called rock flour. It is presence of rock Flour that gives some glacier-fed rivers and lakes their striking blue or turquoise color. [6]

General consensus says that an SS levels below 50mg/L is safe for drip irrigation system while values above 100mg/L will cause plugging, but the complexity and variability of irrigation waters and systems make effective filtration the most sensible approach to controlling hazards posed by suspended solids. [7]

Turbidity is a measure of the cloudiness of water- the cloudier the water, the greater the turbidity. Turbidity in water is caused by suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water. Turbidity is closely related to TSS, but also includes plankton and other organisms. [8]

Also suspended solids affect ultra violet rays (UV) disinfection in two ways. Suspended solids tend to block UV light thus reducing transmittance levels. Secondly, the "shadow effect" makes particles behave like protective shields for microorganisms, occluding them from the inactivating rays of UV energy. Suspended particles of <10 microns in size provide little hindrance to UV disinfection. UV light can penetrate water completely when suspended particles are 10 to 40 microns in size but additional UV demand is required. All particles larger than 40 microns must be removed to assure complete UV light penetration.

Fully automatic self-cleaning filters provide an economical means of removing suspended solids down to below 3 microns from water steams. [9]

There are three methods to evaluate the amount of suspended solids, The EPA's (The U.S. Environmental Protection Agency's) TSS Method stirs and collects the sub-sample by pouring from whole sample container, The Standard TSS method stirs and to draw from the whole sample container, and The ASTM's SSC (suspended sediment concentration) Method uses the whole sample. [10]

Suspended material in streams can and does affect the water quality in many ways. A few of these are: (1) suspended materials contribute to turbidity, (2) by solution it contributes to the hardness and alkalinity of the water, (3) it can give the water an unpleasant odor and/or color, (4) it reduces the penetration of light, hence affecting the photosynthetic activity thereby reducing the phytoplanktonic action this in turn will cause a drop in the oxygen content, (5) if concentrated enough, the suspended load may have a deleterious effect upon organisms (wallen 1951), (6) it can change the water chemistry by adsorption and/or absorption of specific elements and/or chemicals, and (7) sediments may impart to the water an earthy test.[11]

2.3.3 Dissolved solids (TDS):

There are a wide variety of organic substances or dissolved solids in water solution. Common dissolved substances are sodium, chloride, sulfates, calcium, bicarbonate, nitrates, phosphates, iron, and magnesium. TDS concentrations are used to evaluate the quality of freshwater system.TDS concentrations are equal to the sum of positively charged ions (cations) and negatively charged ions (anions) in the water.[12]

TDS is sometimes used as a "watch dog" environmental test. Any change in the ionic composition between testing sites in a stream can quickly be detected by measuring TDS values. This change happen when ions are introduced to water from salts, acids, bases, hard-water minerals, or soluble gases that ionize in solution. However the tests will not tell you the specific ion responsible for the increase or decrease in TDS. [13]

Sources of TDS include agricultural run-off, urban run-off, industrial wastewater, sewage, and natural sources such as leaves, silt, plankton, and rocks. Piping or plumbing may also release metals into the water. While TDS is not considered a primary pollutant, high TDS levels typically indicate hard water and may lead to scale buildup in pipes, reduce efficiency of water filters, hot water heaters, etc., and aesthetic problems such as a bitter or salty taste.

The united state environmental protection agency (EPA) recommends treatment when TDS concentrations exceed 500mg/L or 500 (ppm), but it didn't have a national criterion for TDS. TDS concentrations vary greatly from state to state. For example, Alaska has a criteria of 1000mg/L TDS to protect aquatic life throughout the state, Mississippi has criteria of 750mg/L monthly average for protection fish, wildlife and recreation criteria, and Illinois has a 1500mg/L TDS criteria supporting designated use of secondary contact and indigenous aquatic life standards. The TDS concentration is considered a Secondary Drinking Water Standard, which means that it is not a health hazard. However, further testing may be warranted, as water with a high TDS concentration may indicate elevated levels of ions that do pose a health concern, such as aluminum, arsenic, copper, lead, nitrate and other. [12]

Secondary Water Quality Standards:

The U.S EPA has established the national secondary Drinking Water Regulation (NSDWRs). These secondary standards are non-enforceable guidelines regulation contaminants that may cause cosmetic effects (such as skin tooth discoloration) or aesthetic effects (such as taste, order, or color) in drinking water. EPA recommends secondary standards to water system but does not require systems to comply as shown in **table (2-1)**. [8]

Table [2-1]: secondary water quality standers [8]

Contaminant	**Secondary Standard**
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Dissolved materials at certain concentrations are essential for aquatic life and all have the ability to carry an electrical current. These substances affect the flow of materials in and out of the cells of organisms living in the water and they may also be used as energy sources in certain organisms. The dissolved substances in addition serve as parts of the molecules needed for building new cells. [12]

The salts act to dehydrate the skin of animals. High concentration of dissolved solids can add a laxative effect to water or cause the water to have an unpleasant mineral taste. It is also possible for dissolved ions to affect the PH of a body of water, which in turn may influence the health of aquatic species. If high TDS readings are due to hard-water ions, then soaps may be less effective, or significant boiler planting may occur in heating pipes. [13]

It was reported in a summary of a study in Australia that mortality from all categories of ischemic heart disease and acute myocardial infarction was increased in a community with high levels of soluble solids, calcium, magnesium, sulfate, chloride, fluoride, alkalinity, total hardness, and PH when compared with one in which levels were lower.[14]

The TDS concentrations that cause adverse effects varies substantially with the ion composition. For example, the TDS lethal concentration that causes 50% mortality for an invertebrate species during 48- hour tests ranges from 390mg/L to over 4,000mg/L depending on the ion composition. Studies have shown that, in general for freshwaters the relative ion toxicity was:

$$K^{+}>HCO^{-}=Mg^{+2}>Cl^{-}>SO4^{-2}$$

Ca^{+2} and Na^{+} did not produce significant toxicity. Since TDS toxicity depends on the ion composition, it is recommended that different limits for individual ions, rather than TDS, be used. The State of Illinois is in the process of rule making that replace the TDS criterion of 1000 mg/L with sulfate criteria (a chloride criterion of 500 mg/L is already in the rules). The challenge is what specific ion criteria should be used to replace TDS. Among the potentially most toxic ions, K^+, $HCO3^-$, Mg^{+2}, Cl^- and SO^{-2}, the effluent concentrations for the first three ions are usually relatively low. This approach that state of Illinois is taking with the EPA Region 5 support.[15]

Table (2-2) shows the classification for saline water according to TDS concentration. [16]

Table (2-2): The classification for saline water according to TDS concentration [16]

Classification	**Total Dissolved Solids (mg/L)**
Freshwater	0 – 1000 mg/L
Slightly Saline	1000 to 3000 mg/L
Moderately Saline	3000 to 10,000 mg/L
Very Saline	10,000 to 35,000 mg/L
Briny > 35,000 mg/L	

There are two ways to measure TDS first by evaporation the sample that passed through the filter to remove SS, The second method was a conductivity probe, it offers the advantage that it can be performed without filtration providing instantaneous feedback about TDS concentration in a stream.

TDS may be treated by reverse osmosis (this technology can be costly but it's widely used), electro dialysis de ionizes (is not suitable for high levels of iron, manganese, hydrogen sulfide, chlorine, or hardness), distillation or freezing (higher TDS concentration) and ion exchange (is not effective for treating concentrations lower than 3000 mg/L). [12]

There are many sources of TDS **table (2-3)** shows some of these sources.[13]

Table (2-3): sources of total dissolved solids.

Sources of Total Dissolved Solids
Hard-Water Ions - Ca^{2+} - Mg^{2+} - $HCO_3^–$
Fertilizer in agricultural runoff - NH_4^+ - $NO_3^–$ - $PO_4^{3–}$ - $SO_4^{2–}$
Urban runoff - Na^+ - $Cl^–$
Salinity from tidal mixing, minerals, or returned irrigation water - Na^+ - K^+ - $Cl^–$

2.4 literature reviews of TS, SS and DS on Tigris River:

Previous studies of Tigris River have been done ad bellow are some of them:

Ibtihaj [17] studied the effects of discharging sewage of Baghdad in Tigris River between Al-A`imam bridge and Al-Jumhuria bridge, about

(9km) length with in Baghdad city, which include four sewage stations pumping untreated discharge to the river. It was concluded the concentrations of pollutants were increased at the discharge points in the river and exceeding the acceptable limits according to the Iraqi standards specification of surface water. [17]

Karima [18] studied the environment of the hospitals of medical city in Baghdad; one of the residuals of the medical city is liquid wastes having different components such as sanitary waste water, dangers chemical liquids, medical liquid wastes, radian liquid waste and liquid residual from heavy metals. Most of these liquid wastes are disposed in water treatment plants without the required special treatment. [17]

Karima [18] studied the environment of the General Company for vegetable oils (Baghdad factories); the liquid residuals in all factories are of two parts: one, which is assumed to be none polluted, is disposed directly without treatment, the other which is polluted, is disposed to Tigris River after been treated. [18]

Another study about the environment of oil refineries in Iraq shows the location of these oil refineries and where they dispose the liquid wastes of each refinery. [19]

Dr. Keffah [20] studied the total dissolved solids in Tigris and Euphrates for the year 1981 and 1992 and compared the results for these two years. For Tigris River, it is obvious that TDS are doubled through these years due to the increased effects of the human and industrial wastes. [20]