Self Purification in Al-Saqlawiya Drain in Abu-Grebe

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Abstract

Surface water flow samples were collected with distances downstream over Saqlawiya main drain whose stretch of about 24.5 km. The drain travels through different land use pattern, before, flowing into Tigris River. Eight sampling points were carefully selected downstream the channel during dry season. The examined water parameters were pH, NH_3, NO^-_3, $PO^=_4$, BOD_5, COD, TDS, S.S, Cl^-, $SO^=_4$, Na^+, Ca^{+2}, Mg^{+2}, and Oil and Grease.

Descriptive and inferential methods through finding the best curve fit correlation were employed in the study to test the strength of the association between water chemical characteristics and distance downstream the channel.

A comparison of the values of chemical parameters at the Al-Saqlawiya Drain-Tigris River meeting shows that nine parameters (i.e. pH, NH_3, NO^-_3, $PO^=_4$, BOD_5, COD, TDS, S.S, and Oil and Grease) out of the 14 parameters under study decreased in their concentration at meeting point.

In a further analysis, predictive models were obtained through using six sampling points (0. 1, 3, 5,7, 8) and leaving three (2, 4, 6) as activation function.

The percentage error for the calculated values of pH, NH_3, BOD_5, COD, TDS, Cl^-. $SO^=_4$, Na^+ and Mg^{+2} ranges from (0.54 to 15) % which demonstrate the high predictive capacity of the models.

While the high values of the determination coefficient (r higher than 0.9) for NH_3, NO_3, BOD_5, COD, SS, Cl^-. $SO^=_4$, Na^+, Mg^{+2} and Oil and grease, demonstrate a good model capacity relating water values and distances downstream

Finally the paper concludes that artificial purification efforts at the water works should be directed towards controlling the concentration of Cl^-, $SO^=_4$, Na^+ , Ca^{+2} , Mg^{+2} which increased with increases in distance downstream and suggests further research in the area of monitoring water quality.

Key words: Self purification, Abu-Grebe Dairy factory, Tigris River, Al- Saqlawiya drain, White Gold village

التنقية الذاتية في مبزل الصقلاوية منطقة ابو غريب

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الخلاصة

تم جمع عينات من المياه السطحية الجارية على طول مجرى مبزل الصقلاوية ولمسافة تقدر ب24.5 كم . يجري المبزل ضمن اراض باستعمالات مختلفة قبل ان يصب في نهر دجلة في نهاية المطاف .

تم تحديد ثمانية مواقع على طول مجرى البزل وخلال موسم الجفاف. اما ماتم تحليله من المتغيرات ذات العلاقة بتحديد نوعية المياه السطحية فقد كانت pH وNH_3 وNO_3^- و$PO_4^=$ وBOD_5 و COD و TDS و SS و Cl^- و$SO_4^=$, وNa^+ وCa^{+2} و Mg^+ ، واخيرا وليس اخرا النفط والدهون الثقيلة.
كذلك تم استخدام الطرق الوصفية والاستنتاجية من خلال اختيار افضل منحنى يمثل افضل قوة ارتباط بين خصائص المتغيرات الكيمياوية والفيزياويه والعضوية للمياه السطحية للمبزل والمسافة الخطية نزولا ومع جريان المبزل حتى التقائه بنهر دجلة.
وبمقارنة النتائج للمتغيرات اعلاه عند نقطة التقاء مبزل الصقلاوية مع نهر دجلة تبين ان تسعة متغيرات من اصل اربعة عشر تتناقص في تركيزها مع مسافة الجريان حتى نقطة الالتقاء .

كما تم اختيار موديلات رياضية باستخدام ست نقاط موقعية (0 و 1و3و 5و 7و 8)وتوفير ثلاثة (2و 4 و6) ليتم استخدامها كتطبيق للموديل . ترواحت نسبه الخطأ للقراءات المحسوبة (المخمنة من الموديل الرياضي) من (0.54 الى 15) % بالنسبة ل pH وNH3و BOD5 وCOD وTDS و-Cl و$SO_4^=$ و Na^+ و،Mg^{+2} والتي تشير الى كفاءة الموديل . بينما ارتفاع معامل الارتباط للمتغيرات NH_3 وNO_3^- وBOD_5 و COD و SS و Cl^- و $SO_4^=$,و Na^+وMg^+ ، والنفط والدهون يشير الى وجود علاقة وثيقة بين تغير تركيز هذه المتغيرات مع المسافة الخطية جنوبا .
واخيرا فان البحث يستنتج ان توجه عمليات المعالجة الى معالجة المتغيرات Cl^-و$SO_4^=$,وNa^+ وCa^{+2} وMg حصرا والتي تزايدت مع المسافة جنوبا .كما ويقترح البحث الاستزادة في بحوث متابعة نوعية المياه في هذه المنطقة.

الكلمات الرئيسيه:
التنقية الذاتية، معمل البان ابو غريب ، نهر دجلة، بزل الصقلاوية، قرية الذهب الابيض

Introduction

Self purification potential is a capability by which rivers are enabled to dilute, lessen or eliminate the undesirable effects of entered pollutants. Precise specification of such capability may be considered as a powerful instrument in rivers sustainable management (Mehrdadi and others, 2006). The self-purification capacity of many rivers has been exceeded by far, and they serve now as wastewater collectors in many cities of the world (Ramírez , 2005).

Agricultural practices in many countries still use flood irrigation and uncontrolled use of pesticides and fertilizers. This combination leads to the production of non-point source discharges that increase the river pollution. All the conditions mentioned above imply problems for large- or medium-sized rivers, but are especially critical for small rivers (Corbitt, 2007).
The so-called small-sized rivers (5 to 12 m wide), low depth (0.3 to 0.7 m) and wide river beds (8 to 20 m) have slow and

structured plug flows that result in a slow oxygen transfer from the upper layer to the middle and to the one in contact with bottom sediments (Ramírez, 2005). Nutrients from the river basin or from rain runoff are introduced into the rivers part of the natural cycle. These nutrients allow the survival of bacteria and algae that will transform the organic matter into inorganic compounds, integrating them into the trophic cycle. Rivers under the conditions stated above are called rivers in equilibrium (Ostroumov, 1999). Anthropogenic activities disturb this equilibrium by continuously discharging wastes into rivers, such as domestic and industrial raw wastewater or agricultural non-point sources, producing a decomposition zone, followed by a septic zone, a recovery zone and finally a clean zone. The length of each of these zones depends on the water flow rate, quantity and kind of bacteria (free or attached), nutrient transport and transformation, oxygen uptake and quality and quantity of anthropogenic contaminants (Fair, 1991).

Degradation of contaminants is especially slow in small sized rivers due to low-flow velocity and few free bacteria in the water column. Therefore, the different zones are longer than those in the bigger-sized rivers (Ostroumov, 1999).

Pollution sources that threaten the quality of water in Al-Saqlawiya channel may be classified into two categories namely point and non-point sources. Point pollution sources are those whose waste is discharged in to the river from a specific point. Major pollutants of this category are Abu-Grebe Dairy factory, as well as waste water discharged from the residential area of White Gold Village.

On the other hand, non-point sources whose waste is considered as a distributed load consist of agriculture-related pollutants which are drained towards the channel.

The rapid oxygen consumption of dairy waste discharged into public water will lead to lack of oxygen, much quicker than in the case of domestic sewage (Hammer, 1975).

In Natural River systems, organic matter is assimilated by a number of processes that include sedimentation, which is enhanced by mechanical and biological flocculation, chemical oxidation and the death of enteric and pathogenic microorganisms by exposure to sunlight (Ramírez, 2005).

Biodegradable organic matter is gradually eliminated in rivers due mainly to bacterial action by methods very similar to those occurring in wastewater treatment. Complex organic molecules are broken down to simple inorganic molecules in a process requiring oxygen (Nemerow, 1984).

Wastes which are high in degradable organic matter (such as domestic sewage and dairy wastes) will rapidly use up a stream's dissolved oxygen resources in the decomposition/stabilization process.

In some instances the oxygen levels drop to a very low or zero point. Dissolved oxygen is essential to all higher forms of aquatic life. It is widely accepted that a dissolved oxygen level of 3 to 5 milligrams per liter is the minimum required to support a balanced population of aquatic flora and fauna. A lower level can be tolerated in drainage canals, where there is little or no fish life, but it must be kept above zero in order to avoid foul odors or other nuisances (Churchill, 1994).

However, since majority of the inhabitants in this area have no access to treated water, people generally lives directly on polluted streams where quality of water depended solely on the extent of natural cleansing. The drain channel under study receives highly polluted sources and empties ills water into Tigris River. There is therefore a need to determine evidences (if any) of the processes of self purification and also identify which of the water chemistry variable are affected by the process of self purification using fourteen classical indicators pH, Ammonia (NH_3), Nitrate (NO^-_3), Phosphate (PO_4^{-3}), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Suspended Solids (SS), Chlorides (Cl^-) ions, Sulphate ($SO^=_4$) ions, Sodium (Na^+) ions, Calcium(Ca^{+2}) ions, Magnesium (Mg^{+2}) ions, and Oil and Grease.

The Study Area

Al-Saqlawiya channel is a drain and storm water open channel. Verifications agree among themselves that this drain was a rivulet in a series of four rivulets used to irrigate area enclosed between Tigris and Euphrates. The four rivers used to reduce the Euphrates flooding problem flow in a north-easterly direction to discharge into Tigris River (Sussa, 1981).

The channel flows through farmland and intermittently receives wastewater from Abu Grebe Dairy factory at the north reach of the drain. Al-Saqlawiya channel is about 24.50 km long, it flows through densely populated areas around the middle and lower reaches before draining Periodically into Tigris River (Al-Ferej, 1983), (figure 1).

The riparian population is largely poor and inadequately provided with basic sanitation or portable clean water. As a result, most riparian inhabitants and itinerant herds' men depend largely on the open channel for their daily water needs. People and livestock visit the channel regularly and undertake activities within or beside the drain, and because of people's attitude huge amount of domestic waste are generated which are not properly disposed off, but are dumped indiscriminately along streets, open spaces and on the bank of the channel. In absence of sewerage system, people are using septic tanks and soak pits. In most of the places sewage is discharged into open sub drains without any treatment, ultimately discharged to Al-Saqlawiya drain.

Average temperature is high throughout the year (about $37^{O}C$). The flow pattern exhibited by the drain is highly patterned along the incidences of rainfall. The river exhibits higher velocity and greater volume during rainy season, but almost dries up during the dry season (Al-Ansari and Al-Sinawi, 1995).

The retention time for the channel effluents in this reach is estimated about 9 hours under calm and dry weather conditions. But under heavy rainfall, whose discharge can be up to 5 times the dry weather discharge, the lower extreme of retention time is 6 hours (Al-Ferej, 1983).

Materials and Method of Study

Sampling occurred during the absence of precipitation. The period was ideal since in-channel activities are frequent in dry weather and channel velocity is very low during this period.

Thus, a reasonable duration of stream flow was guaranteed and temporary contamination generated by surface runoff and resuspension of contaminated sediments by turbulent flow was reduced.

Standard analytical procedures (APHA, 1995) were followed for Suspended Solids (SS), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Sulphate, TDS, Cl^- and Ammonia. Direct determinations with a spectrophotometer at UV437 were made for turbidity, using 5cm quartz cuvette and the results reported as absorbance per meter (Abs. m^{-1}).

Na^+ was analyzed using a flame analyzer while Mg^{+2} and Ca^{+2} were analyzed using atomic absorption spectrometer. The pH was determined by glass electrode pH meter, NO^-_3 by colorimetric method using phenol disulphonic acid and phosphorous by bray method.

The inferential method employed which is the product moment linear correlation statistics was used to test the strength of the association between water chemical characteristics and distances downstream the drain channel, and between the parameters themselves.

Fig.1 Al-Saqlawiya Drain showing the sampling points

Methodology

The methodology involved was walking the whole length of the channel, carrying out a visual inventory, collecting samples from preselected sites as exposed in table 1. Samples were collected once a month during the dry months scooped up from below the water surface at midstream and bottled in precleaned glass flasks. Filled sample flasks were sealed free of air bubbles with glass stoppers and stored in darkness at a temperature of approximately $4^{O}C$.

Table 1: Sampling points descriptions

Station no.	Location description
0	Meeting point of Al-Saqlawiya Drain and Dairy discharge
1	0.25km downstream pt. 0
2	0.5km downstream pt.0 along Al-Saqlawiya Drain
3	1km downstream pt. 0 along Al-Saqlawiya Drain
4	3km downstream pt 0
5	7km downstream point 0
6	11km downstream pt.0
7	Al-Shaul'a pumping station (17km downstream pt.0)
8	Al-Saqlawiya Drain -Tigris River meeting pt.(24.5 km downstream pt. 0)

The samples were tested in the laboratory for the parameters mentioned above.

Results

Descriptive Characteristics Of Chemical Parameters

The results of the descriptive statistics show that the means of the chemical parameters vary from one parameter to the other (Table 2). For example, it ranges from 2494.6 mg/l for water total dissolved solids, to 0.92 mg/l for phosphates ions. On the extent of the variation between each of these chemical parameters and their mean the result of the standard deviation vary from one parameter to the other. This ranges from 1109.5 mg/l for total dissolved solids to 0.584 for pH. On the relative deviation from one sample point to the other, the result of the coefficient of variation showed that seven parameters (PO^{-3}_4, BOD_5, COD, TDS, $SO^{=}_4$, Na^+, Mg^{+2}, having heterogeneous distribution due to high coefficient of variation that is greater than 33%. The implication of the above is that these parameters vary on the nature of their occurrences. This point to the fact that water chemistry properties along the channel is highly variable, suggesting that there is a need for close monitoring of chemical parameters for the purposes of water resource management in the study area.

Table 2: Descriptive characteristics of water samples

Variable	pH	NH_3	NO^-_3	PO^{-3}_4	BOD_5
Mean	7.74	2.54	16.18	0.92	32.31
Standard Deviation	0.584	0.917	4.276	0.738	194.1
CV%	7.5	30.1	26.4	80.1	60.0
Variable	**COD**	**TDS**	**SS**	**Cl^-**	**$SO^{=}_4$**
Mean	68.40	2494.6	76.37	1242.8	2249
Standard Deviation	43.30	1109.5	14.9	446.38	980.8
CV%	63.3	44.4	19.5	30.0	43.6
Variable	**Na^+**	**Ca^{+2}**	**Mg^{+2}**	**Oil& Grease**	
Mean	974.78	288.1	105.8	21.5	
Standard Deviation	392.4	113.97	82.5	17.18	
CV%	40.25	30.5	77.9	79.9	

Spatial Characteristics of Water

All the chemical parameters vary in their concentration. pH initially at the source was 10.0, it changed to7.5 mg/l at point 7 and later to 8.1 at the mouth of the river

(Sample point 8) (Fig. 2a). The value of NH_3 increased from 2.75 mg/l at the source to 9.0 mg/l in sampling point 7, and then decreased to 0.4 mg/l at river's mouth. NO^-_3 initially was 71.6 mg/l; it went down to 13.1 mg/l on sampling point 2. This later decreased to 5.5 mg/l (Fig. 2c). Phosphates decreased from 3.64 mg/l at the source to .04 mg/l but further increased to 0.43 mg/l (Fig. 2d). BOD had an initial extreme value of 1860 mg/l, yet it experienced a noticeable decrease to 7.2 mg/l at point 4 and 5, this changed to 100.0 mg/l, 15.0 mg/l and finally to 2.0 mg/l at sample point 8(Fig. 2e). COD at the source was 147 mg/l; it went down to 99.1 mg/l in sample point 2 and to 8.86 mg/l at sample point 8. Water Total Dissolved Solids had an initial value of 3047 mg/l, increased dramatically to 5780 mg/l at sampling point 6, this increase may possibly due to irrigation flow over and finally was diluted to 712.0 mg/l at sampling point 8, (Fig.2g). Suspended particles decreased from 290 mg/l at source to 60.50 mg/l at point 1 and finally decreased to 27.60 mg/l at the meeting point (Fig. 2h). The value of Cl^- increased from 1480.00 mg/l at the source to 2512.0 mg/l, but back off to 156.9 mg/l at the channel mouth (Fig 2i). The value of $SO^=_4$ increased dramatically from 356.5 mg/l at the source to 2512 mg/l at point 1, and further more to 2675.0, 2800 and 3000 mg/l at sampling points 5,6 and 7. A value of 900.7 mg/l was reported in point 8 (Fig 2j). Na^+ initially was 445 mg/l; it went up sharply to 1600 mg/l at point 1. This later decreased to 560 mg/l at sample point 8 (Fig 2k). This increase may possibly due to riparian inputs.

Ca^{+2} had an initial value of 82.4 mg/l this increased to 416 mg/l at sample point 1 and later on diluted to 210 mg/l at sample point 8 (Fig. 2l). Mg^{+2} increased from 19.5 mg/l at the source to 61.4 mg/l as it arrives the mouth, (Fig. 2m). Finally Oil and Grease was 54.7 mg/l at the source but it kept swinging.15.4, nil, 5 mg/l, nil, as the channel flow in Tigris River (Fig. 2n).

The high variability in concentration of water chemistry is an expected result of land use changes coupled with the impact of self purification processes, which has either increased or decreased concentration of water chemical parameters in the study area.

Al-Saqlawiya Drain Self Purification

A comparison of the chemical parameters values at the Drain-Tigris meeting (sampling point 8) shows that nine parameters (pH, NH_3, NO^-_3, $PO^=_4$, BOD_5, COD, TDS, S.S, and Oil and Grease) out of the 14 parameters decreased in their concentration. This might be due to processes such as oxidation, sedimentation, and volatilizion (Oldaker, 1999).

Hence, water parameters are likely to be present in lower concentration in the drain-river joining point, while other parameters must have added into their concentration probably from riparian inputs or plants senescence along the river channel. This consequently suggests a need to examine the concentration of these other parameters in some details for the purpose of environmental management.

In a further analysis, predictive models were obtained through using six sampling points (0. 1, 3, 5,7, 8) and leaving three (2, 4, 6) as activation function. Table 3, expose the performance of different models estimated for the six points only, while table 4 shows the calculated value corresponding the actual value and the mean percentage error by applying the spared three points (2, 4 and 6).

The percentage error for the calculated values of pH, NH_3, BOD_5, COD, TDS, Cl. SO_4, Na, Mg^{+2} ranges from(0.54 to 15)% which demonstrate the high predictive capacity of the models.

The high values of the determination coefficient (r higher than 0.9) for NH_3, NO_3, BOD_5, COD, SS, Cl, SO_4, Na, Ca, Mg. and Oil and grease, demonstrate a good model capacity relating water values and distances downstream as concentration tends to decrease from the point source downstream as time elapses. However there are other water parameters where the concentration increases downstream, for it must be noted that the conservative pollutant show higher concentration than the non-conservative pollutant. This is because the mass of the former is conserved while the latter decays via various factors such as oxygenation.

One can therefore conclude that artificial purification efforts at the water works should be directed towards controlling the concentration of the increased parameters concentration downstream just mentioned.

The paper suggests further research in the area of monitoring water quality of the parameters. This will be more important at a future date, when the pollutant loadings in the water body might have increased particularly due to anthropogenic influence in the study area.

River Potability

A comparison of the values of water chemistry at the rivers mouth with the Iraqi Standards, 417/2001 for drinking water and "system of Preservation of Water Sources no. 2 dated 2001" (table 5)shows that five out of the fourteen parameters (Cl^-, $SO^=_4$, Na^+, Ca^{+2} and Mg^{+2}) exceeded the Iraqi Standards. Also, these five parameters have been found to increase with distances downstream. Other water parameters fell short of the required limits. Excess concentration of Cl^-, $SO^=_4$, Na^+ Ca^{+2} and Mg^{+2} may probably due to riparian inputs from the surrounding farmlands, this has been noted to aggravate hypertension in adults and also to elevate blood pressures in children (WHO, 2006). The high COD can be indicative of the extent of chemical pollution from the riparian land use, in form of leachate from chemical fertilizers and forms of herbicides from farmlands. Both phosphate and nitrogen cause eutrophication in surface water bodies. It is apparent that the nitrogen values were increased after each sewerage scheme.

Table 3: Space/time model, for five in between sampling points.

Parameter	Model fit
pH **r=0.848**	**Exponential Association:** $y=a(1-e^{-bx})$ **a =7.409E+000** **b = 1.587E-002,**
NH_3 **r=0.958**	**Exponential association:** **, a=1.087 b=0.149** $e^{-bx})$**y=a(1-**
NO^-_3 **r=0.989**	$\frac{1}{a+bx^c}$ **Harris Model : y=** **a =-6.945E-001,b =5.272E-001** **c =6.419E-002**
PO^{-3}_4 **r=0.882**	**Harris Model : y=** $\frac{1}{a+bx^c}$ **a =6.193E+000, b =-6.00E-002** **c =1.991E+000,**
BOD_5 **r=0.999**	**Harris Model: y=** $\frac{1}{a+bx^c}$ **,** **a =5.376E-004, b =9.431E-005** **c =8.548E-001**
COD, **r=0.959**	**Harris Model y=** $\frac{1}{a+bx^c}$ **a =-4.121E-001, b =4.094E-001** **c =5.055E-003**
TDS **r=0.861**	**Quadratic Fit:** $y=a+bx+cx^2$ **a =5.622E+002, b =7.462E-001** **c =-2.992E-005**
S.S **r=0.993**	$\frac{1}{a+bx^c}$ **Harris Model: y=** **a =-1.991E-001, b =1.592E-001** **c =5.229E-002,**
Cl^- **r=0.974**	**MMF Model:** $=(ab+cx^d)/(b+x^d)$ **a =-5.686E+000,b =2.067E+007** **c =1.891E+003,d =3.267E+000**
$SO^=_4$ **r=0.993**	**MMF Model:** $y=(ab+cx^d)/(b+x^d)$ **a =-8.485E+000, b =5.249E+007** **c =2.577E+003,d =3.552E+000**
Na^+ **r= 0.996**	**MMF Model:** $y=(ab+cx^d)/(b+x^d)$ **a =5.658E-001, b =4.315E+003** **c =1.390E+003, d =1.652E+000**
Ca^{+2} **r=0.997**	**MMF Model:** $=(ab+cx^d)/(b+x^d)$ **a =-4.682E-001, b =1.206E+005** **c =3.267E+002, d =2.311E+000**
Mg^{+2} **r= 0.985**	**Gunary Model** $=x/(a+b^x+c^{sqrt(x)})$ **a =-2.989E+000, b =9.849E-003** **c =2.341E-001,**
Oil and Grease **r= 0.998**	**Harris Model:** $y=1/(a+bx^c)$ **a =-2.594E+000. b = 1.202E+000** **c =1.682E-001,**

Table 4: calculated value, actual value and the mean percentage error for the spared three points (2, 4 and 6).

Parameter	Calculated (actual)	Error%
pH	**7.40,7.41, 7.41 (7.15),(7.34), (7.46)**	**0.54%**
NH_3	**1.26, 0.188, 5.172 (0.75, 0.55, 4.77)**	**9.39%**
NO^-_3	**10.973, 5.35, 3.793 (9.54, 9.81, 8.65)**	**-39.2%**
PO^{-3}_4	**1.75, 0.129, .021 (0.07, 0.51, 0.43)**	**46.8%**
BOD5	**77.5, 11.22, 3.71 (15, 44, 22.8)**	**11.5%**
COD	**107.3, 70.15, 58.59 (99, 67.8, 33.8)**	**15%**
TDS	**927.83, 2531.51, 5150.24 (456, 1500, 5780)**	**10.14%**
S.S	**47.06, 23.31, 16.69 (86.5, 52.4, 31)**	**94.5%**
Cl-	**1834.14, 1891.95, 1891.95 (1480, 1983, 1842)**	**10.9%**
SO=4	**2543.49, 2577.98, 2566.46 (2512.1, 2637.7, 2325.3)**	**2.92%**
Na+	**1209.64, 1380.3, 1389.74 (1668, 1000.6, 945.9)**	**9.22%**
Ca+2	**307.13, 327.81, 328.1 (566, 470, 448)**	**55.3%**
Mg+2	**69.72, 76.16, 84.66 (71.2, 70.2, 71.2)**	**7%**
Oil and Grease	**1.2, 0.49, 0.31 (0, 0, 5)**	**150.50%**

Table 5: Drinking water standard and Preservation of Water Sources System no. 2dated

arameters	Values at Drain-River meeting, point (8)	Iraqi Drinking water Standards 417/2001 Max.	Water quality limits to be assured in the water bodies according to the Iraqi legislation " Preservation of Water Sources System no.2 dated 2001, (B-1)
pH	8.1	8.5 unit	6.5-8.5
NH_3	0.4	--------	---------
NO^-_3	5.5	50	-------
PO_4	0.43	-------	-------
BOD_5	2	-------	40
COD	8.6	-------	100
TDS	712	-------	-------
S.S	27.6	nil	-------
Cl^-	1000	250	-------
$SO^=_4$	900.7	500	-------
Na^+	560	200	-------
Ca^{+2}	210	50	-------
Mg^{+2}	61.4	50	-------
Oil and Grease	nil	-------	10

Conclusions

The study showed that water chemical parameters vary in both relative and absolute terms. This is clearly shown by the descriptive statistics.

The process of self- purification can be said to operate in the study area since most of the chemical parameters examined reduction in their concentration at the drain-river meeting (sample point 8) compared to their initial concentration.

A decrease in concentration was noticed for the parameters pH, NH_3, NO^-_3, $PO^=_4$, BOD_5, COD, TDS, S.S, and Oil and Grease. While other parameters, of Cl^-, $SO^=_4$, Na^+, Ca^{+2} and Mg^+ appeared to have gained more materials downstream probably , from the riparian land use comprising mainly farmlands. Hence, purification efforts along the channel should be directed to the control of these parameters.

On the state of stream water Potability, a comparison with local standards of drinking water and preservation of surface water system showed that only five parameters (Cl^-, $SO^=_4$, Na^+, Ca^{+2} and Mg^+) exceeded the maximum permissible limit of the national standards. Therefore, water treatment effort should be directed towards examining and reduction of the concentration of the above mentioned parameters.

The comparison between the response of the model to the environmental variables on one hand, and results from field observations on the other the hand, shows similarities and indicates that the current modeling can be trusted. The result can be considered satisfactory since the model built up from set of data obtained in the same geographic area.

Acronym and abbreviations

BOD_5 :Biological Oxygen Demand
Ca^{+2}: Calcium ions
Cl^- : Chloride ions
COD: Chemical Oxygen Demand
Mg^{+2} : Magnesium ions
Na^+ : Sodium ions
NH_3:Ammonia
NO_3^-: Nitrate ions
pH: Acidity measurement
$PO^=_4$: Phosphate ions
r: Correlation value
S.S : Suspended Solids
$SO^=_4$: Sulphate ions
TDS: Total Dissolved Oxygen

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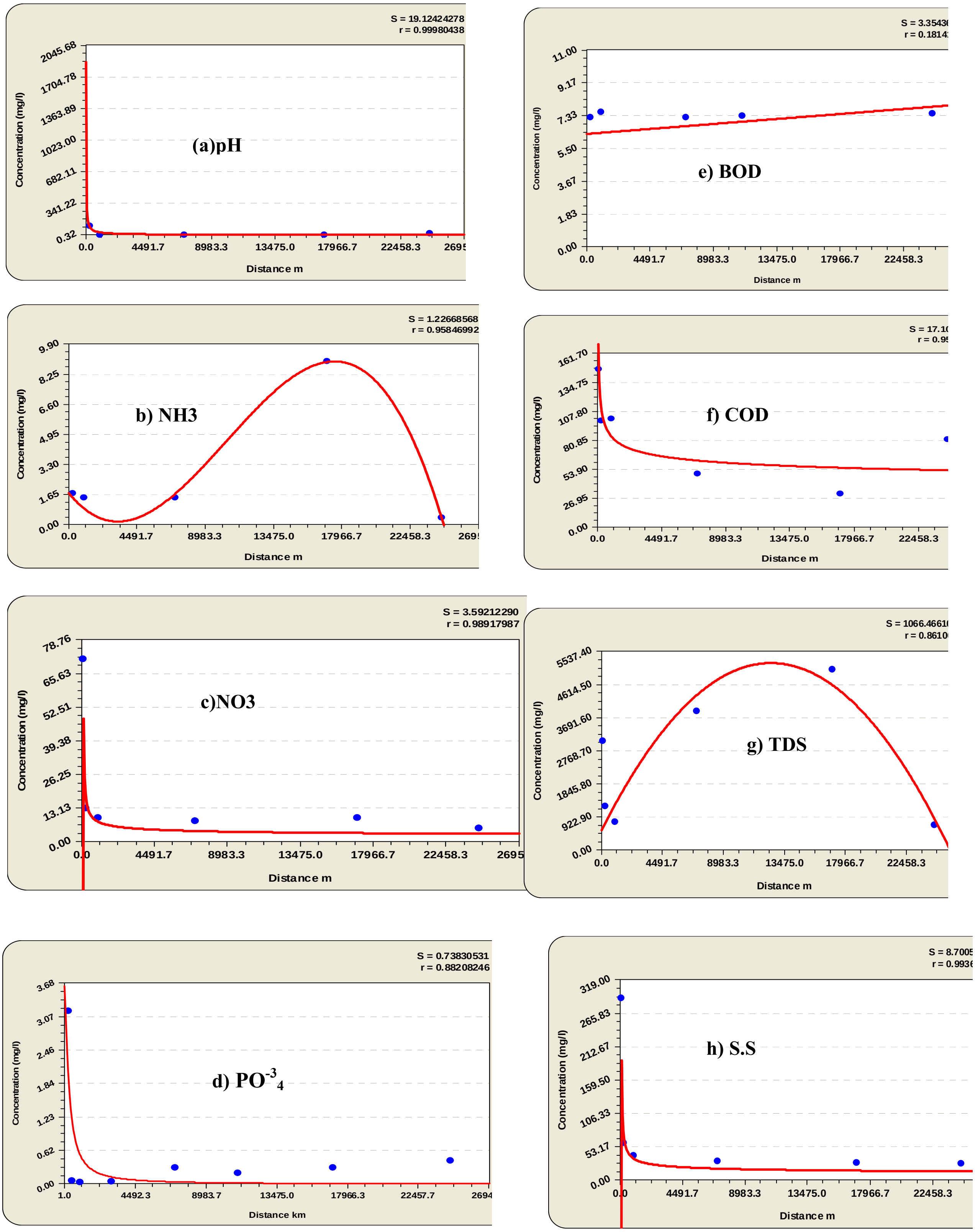
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r = 0.99980438
Concentration (mg/l)
Distance m
b) NH3
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r = 0.95846992
Concentration (mg/l)
Distance m
c)NO3
S = 3.59212290
r = 0.98917987
Concentration (mg/l)
Distance m
d) PO-34
S = 0.73830531
r = 0.88208246
Concentration (mg/l)
Distance km
e) BOD
Concentration (mg/l)
Distance m
f) COD
Concentration (mg/l)
Distance m
g) TDS
Concentration (mg/l)
Distance m
h) S.S
Concentration (mg/l)
Distance m

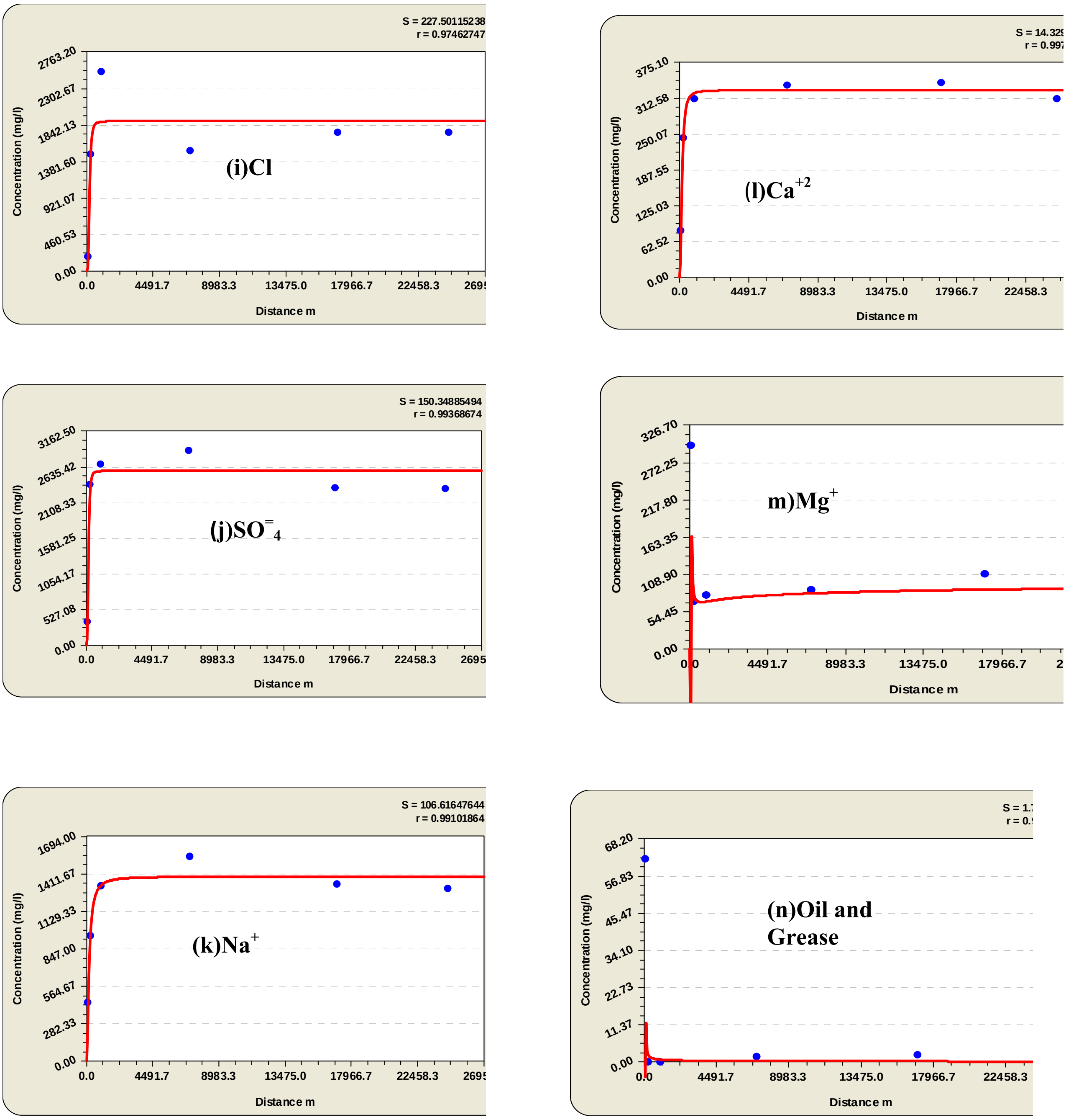

Fig 2: (A-N) Graphical Representation of the Self – Purification Mechanisms in Al- Saqlawiya Drain