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VERIFYING RIVER BANK FILTRATION APPLICABILITY IN IRAQ AGAINST IRAQI'S STANDARDS

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Abstract: In terms of the importance of constructing mega agricultural projects in Iraq and within the rising water conflicts among its surrounding neighbors, this research was initiated with the objective of investigating an innovate technique to improve water quality of the river. Primarily, literature was reviewed in the field of solutions to water scarcity. Apparent was that many techniques are available, from which ***R***iver ***B***ank ***F***iltration "RBF" was selected to be investigated to inspect its applicability and to test it against Iraqi's standards. Field visits were carried out along Tigris River, where data was assembled and 24 wells were dug perpendicular to the river centerline along 4 lines, 500 m apart. Each line had 4 near-wells, 5 m apart, and 2 far-wells, 100 m apart, on each line. A sampling campaign was carried out in November 2021 and water samples were extracted from the 16 near-wells, 8 far-wells and Tigris River. The laboratory results were obtained; plotted onto graphs; analyzed and tested against Iraqi's standards. Based on the laboratory results analysis, apparent was that the water identities were within the Iraqi's standards. Accordingly, the research results highlighted the necessity of RBF technique application to improve water quality of Tigris river. It was further recommended to validate the results against ***international standards***.

Keywords: River bank Filtration (RBF), Tigris River, Water Scarcity, water conflict, Iraq, Desalination Concept.

1. Introduction

Historically, RBF started in Europe. since the 1870s. Recently, wells are the source of water supply to some communities along the Rhine. In addition, such wells are the source of public water supply for many large cities along major rivers in Europe. In the United States, the use of RBF systems began less than 50 years ago. However, interest of implementing RBF is growing worldwide, where table (1) lists bank filtration systems in Europe and the United States.

Table 1: RBF systems worldwide

Localization	Number of wells[a]	Capacity (m^3/s)	Distance to river (m)	Travel time (d)	K (m/s, 10^{-4})[b]	River
Csepel, Budapest, Hungary	>500V	3.7		6 – 14		Danube
Dresden-Tolkewitz, Germany	71V	0.46	80 – 180	25 – 50	10 – 20	Elbe
Düsseldorf, Germany	18H	3.76	50 – 70	10 – 60	40 – 200	Rhine
Mockritz, Germany	74V	1.26				Elbe
Torgau-Ost, Germany	42V	1.74	300	80 – 300	6 – 20	Elbe
Zürich, Switzerland	4H	1.74				Limmat
Maribor, Slovenia	13V	0.75			20 – 40	Drava
Sonoma County, California	6H + 7V	4.92	0 – 75	4.9	2.4 – 4.3	Russian
Cincinnati, Ohio	10V	1.75			8.8 – 15	Great Miami
Columbus, Ohio	4H	1.75				Scioto/Big Walnut
Cedar Rapids, Iowa	2H + 54V	1.49	9 – 245	2 – 17	1.5 – 11	Cedar
Galesburg, Illinois	1H	0.44				Mississippi
Independence, Missouri	1H	0.66				Missouri
Kansas City, Kansas	1H	1.75				Missouri
Boardman, Oregon	2H	1	3 – 18	<1	37	Columbia
Lincoln, Nebraska	2H + 44V	1.53	<30 - >800	<7 – >14	14	Platte
Sacramento, California	1H	0.44				Sacramento

2. Literature Review

Literature in the field of RBF was assembled from previous researches, reports and journals. The assembled literature was comprehended; scrutinized and categorized.

Based on the categorized literature, clear was that water scarcity forced humanity to search for innovative safe water supply techniques. Among them are, RBF, desalination and water from air zero mass water; figures (1), (2) and (3), respectively.

Focusing on the scrutinized literature, apparent was that researchers acknowledged RBF in various ways. For example [1] stated that RBF is an inexpensive efficient technique that improves water quality. [2], [3] advocated that the filtrated water from the river undergoes sorption and physic-chemical filtration so as biodegradation. These processes extract the micro-pollutants so as suspended particles and inorganic compounds. [4]; [1] stated that RBF was acknowledged in Europe to cover drinking water demand, where they mentioned France and Germany, as RBF cover their demand by 50 and 16%, respectively. They stated that RBF is an important supply source that should be protected against upcoming challenges. [4] mentioned that RBF is a century experience, where its schemes are based on empirical knowledge. [5] documented that the physical and biogeochemical processes during RBF provide proper management to RBF systems. [6]; [5] stated that if Groundwater is below riverbed, river water would infiltrate through unsaturated zone. [7] stated that RBF in alluvial aquifers have high abstraction rates. [8] accredited the removal of pathogenic to Residence-Time. ***FOEN (2012b)*** reported that the Residence-Time should be delimited by law.

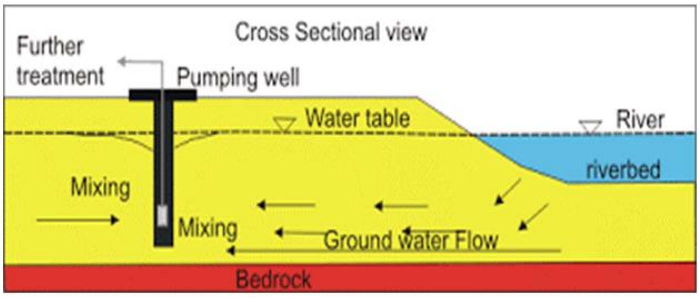


Fig 1: River Bank Filtration Concept

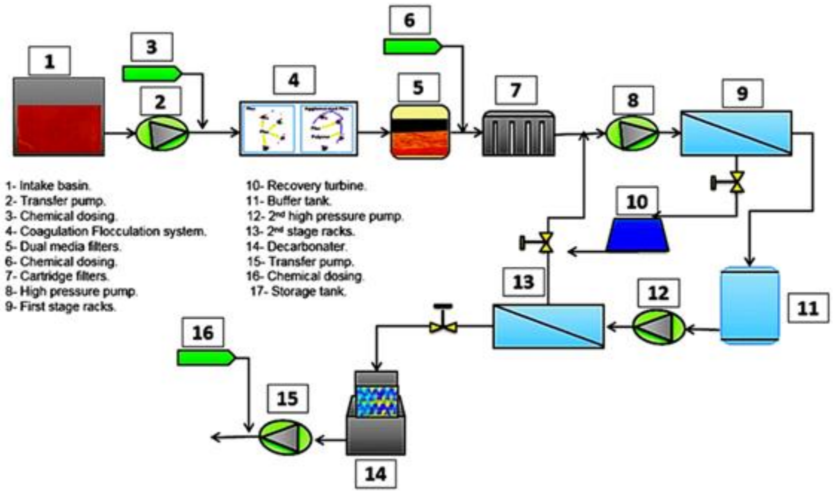


Fig 2: Desalination concept

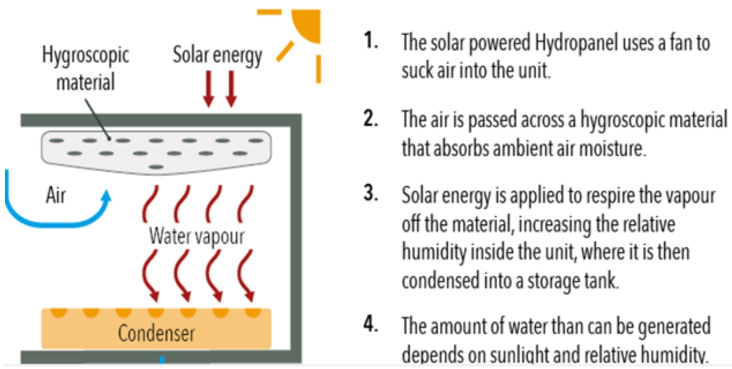


Fig 3: Water from air zero mass water concept

3. Field Visits

Site visits were achieved through 2021-2022, where data labeling the study-area was accumulated and preliminary site inspection was accomplished; photo (1). Information was gathered from native citizens. Soil borings were realized; figure (4). Obvious was that the higher layer is clay of 7-8 m thick, while the inferior layers were 2-7 m thick of coarse sand so as gravel.

From the site inspection, apparent was that the infiltration of river water and groundwater into wells through a soil layer thickness of 23 m, where figure (5) presents a section showing the RBF process.

Throughout the site visits, 24 wells were drilled (i.e. 16 near-wells were dug along 4 lines perpendicular to Tigris Bank that were 500 m apart). Each line encompassed 4 wells at 5, 10, 15 and 20 m from Tigris bank. In addition, 8 far-wells were dug, 2 along each line at 100 and 200 m away from Tigris Bank.

Also, water samples were extracted from near-wells, far-wells and Tigris River; photos (2) and (3) present field inspection and drilling of wells.

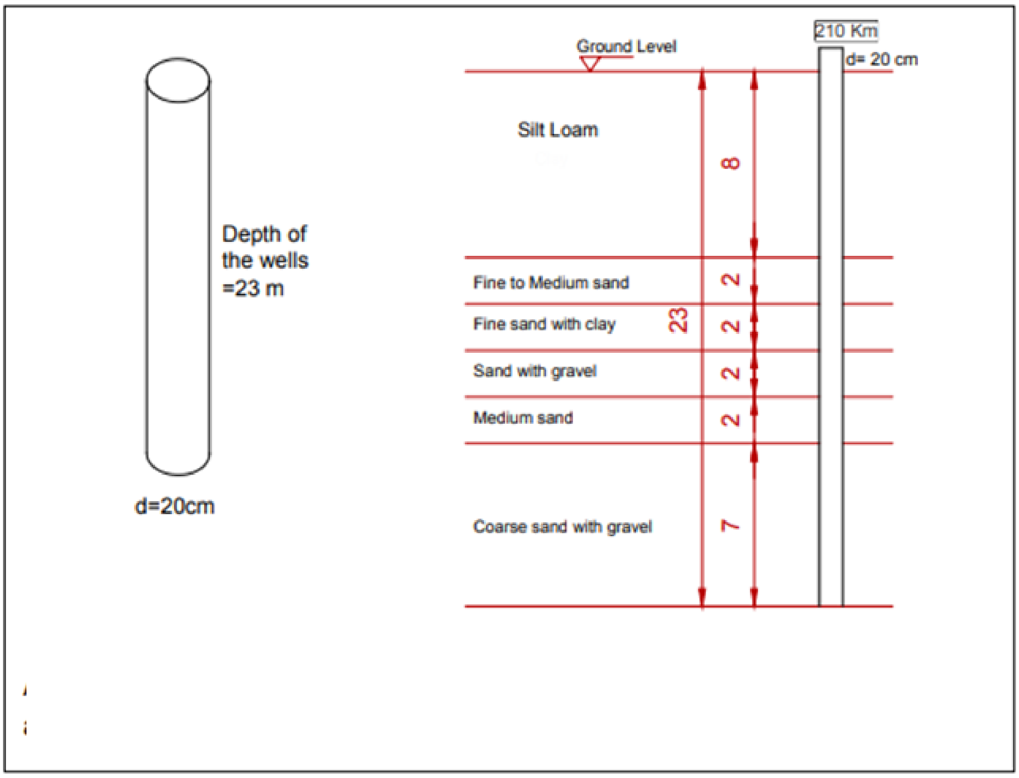


Fig 4: Soil Stratification at the study area at 210 km South Mousel Dam

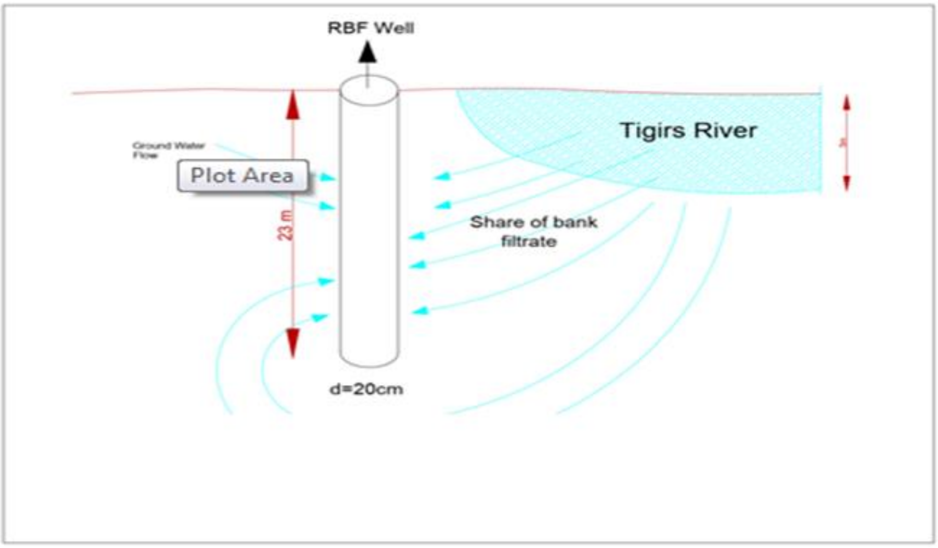


Fig 5: RBF process at the study area

Photo 1: Study-area location map

Photo 2: Site visits

Photo 3: Drilling of wells

4. Site Description

From the site visits, a description to the study area is summarized, as follows:

- The study area is along Tigris left bank, 200 km South of Mosul Dam; photo (4).
- It is a sedimentary land with layers from ancient and modern geological ages.
- It is cultivated with many crops (i.e. barely), vegetables (i.e. eggplant) and fruits (i.e. figs).
- It is hot dry in summer and cold rainy in winter with agricultural diversity.

5. Drilling of Wells

four lines at 210.0, 210.5, 211.0, 211.5 km, South of Mousel Dam were aligned perpendicular to the riverbank, spaced by 500 m. Along each line, 4 near-wells were dug at 5, 10, 15 and 20 m from riverbank and 2 wells were drilled at 100 and 200 m from Tigris Bank on each line. All wells were 23 m deep lined with pipes of 20 cm diameter. Figure (6) presents the alignment of the 16 near-wells.

Photo 4: Mosul Dam

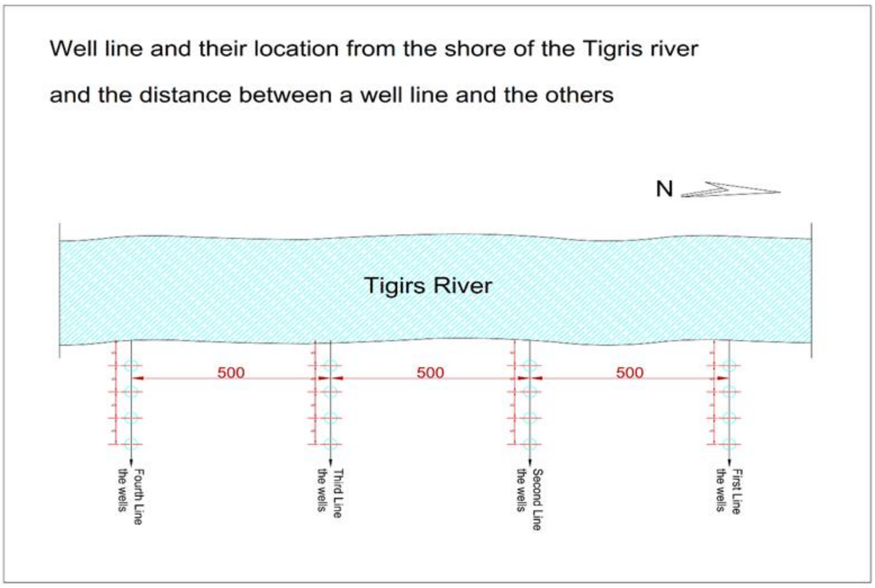


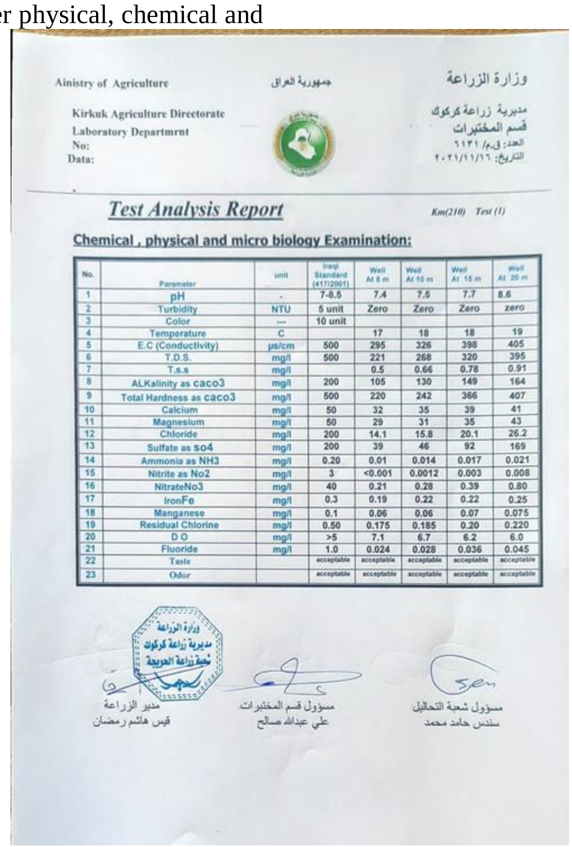
Fig 6: 16 near-wells

6. Data Sampling

After drilling of wells, a large sampling campaign was carried out in November 2021. During the campaign, water was pumped off for 4 hours, after which 28 samples (16 from near-wells, 8 from far-wells and 4 from Tigris River) were extracted.

The samples were analyzed in skilled laboratories of the Ministry of Agriculture and Kirkuk Agriculture Directorate to determine their water physical, chemical and biological quality parameters, based on 23 WQ parameters; table (2).

In total, 588 results were obtained (644 is the result of multiplying 28 samples, 23 WQ parameters). The 644 results were tabulated on authorized laboratory certificates, where photo (5) is given, as a sample that describes the tabulated 23 parameters of the 4 near-wells drilled along the line located 210.0 km South of Mousel Dam.



Ainistry of Agriculture

جمهورية العراق

وزارة الزراعة

Kirkuk Agriculture Directorate
Laboratory Departmrnt
No:
Data:

مديرية زراعة كركوك
قسم المختبرات
العدد: ق.م/ ٦١٣١
التاريخ: ٢٠٢١/١١/١٦

Test Analysis Report *Km(210) Test (1)*

Chemical , physical and micro biology Examination:

No.	Parameter	unit	Iraqi Standard (417/2001)	Well At 5 m	Well At 10 m	Well At 15 m	Well At 20 m
1	pH	-	7-8.5	7.4	7.5	7.7	8.6
2	Turbidity	NTU	5 unit	Zero	Zero	Zero	zero
3	Color	---	10 unit				
4	Temperature	C		17	18	18	19
5	E.C (Conductivity)	µs/cm	500	295	326	398	405
6	T.D.S.	mg/l	500	221	268	320	395
7	T.s.s	mg/l		0.5	0.66	0.78	0.91
8	ALKalinity as caco3	mg/l	200	105	130	149	164
9	Total Hardness as caco3	mg/l	500	220	242	366	407
10	Calcium	mg/l	50	32	35	39	41
11	Magnesium	mg/l	50	29	31	35	43
12	Chloride	mg/l	200	14.1	15.8	20.1	26.2
13	Sulfate as so4	mg/l	200	39	46	92	169
14	Ammonia as NH3	mg/l	0.20	0.01	0.014	0.017	0.021
15	Nitrite as No2	mg/l	3	<0.001	0.0012	0.003	0.008
16	NitrateNo3	mg/l	40	0.21	0.28	0.39	0.80
17	IronFe	mg/l	0.3	0.19	0.22	0.22	0.25
18	Manganese	mg/l	0.1	0.06	0.06	0.07	0.075
19	Residual Chlorine	mg/l	0.50	0.175	0.185	0.20	0.220
20	D O	mg/l	>5	7.1	6.7	6.2	6.0
21	Fluoride	mg/l	1.0	0.024	0.028	0.036	0.045
22	Taste		acceptable	acceptable	acceptable	acceptable	acceptable
23	Odor		acceptable	acceptable	acceptable	acceptable	acceptable

وزارة الزراعة
مديرية زراعة كركوك
شعبة زراعة الحويجة

مدير الزراعة
قيس هاشم رمضان

مسؤول قسم المختبرات
علي عبدالله صالح

مسؤول شعبة التحاليل
سندس حامد محمد

Photo 5: Sample of authorized certificates with 23 results of the 4 near-wells along 210.0 km line South Mousel Dam

Table (2) Inspected WQ parameters

Inspected WQ parameters		
pH value	Alkalinity CaCO3	No2: nitrite
Turbidity	Total Hardness CaCO3	No3: nitrate
Color	Ca: Calcium	Fe: Iron
Temperature	Mg: Magnesium	Mn: manganese
EC: Electrical Conductivity	Chloride	Residual Chlorine
TDS: Total Dissolved Solids	So4: sulfate	Do: dissolved Oxygen
Tss: Total Suspended Matter	NH3: Ammonia	Fluoride

7. Analyzing Results and Discussing RBF Verification

The laboratory results were analyzed to verify RBF applicability in Iraq. Water samples from ***near-wells***, ***far-wells*** and ***Tigris River*** in November 2021 were plotted on graphs and verified against Iraqi's specifications.

Only the results of 18 parameters were presented, as a sample of the designated 23 parameters. These were EC, TSS, CaCo3, Ca, TDS, Alkalinity, Residual Chlorine, Mg, SolSo4, NH3, Fluoride, Cl, pH, No2, No3, Mn, DO and Fe.

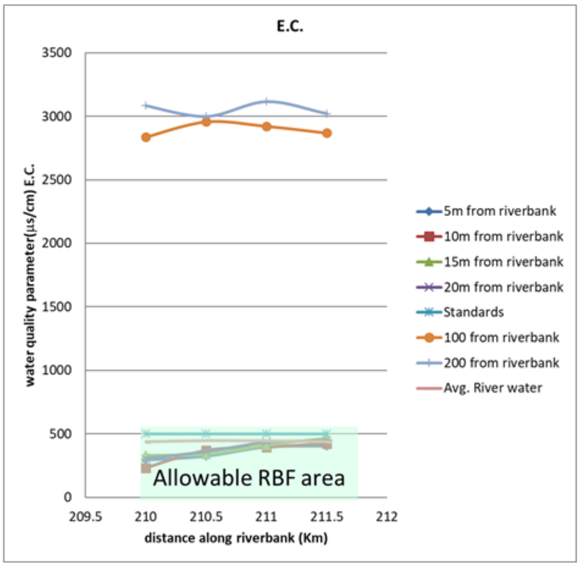
These results were obtained during the wide measuring campaigns that were carried out in ***November 2021***; graphs (1) to (18).

On the figures, a green area and a blue line were superimposed:

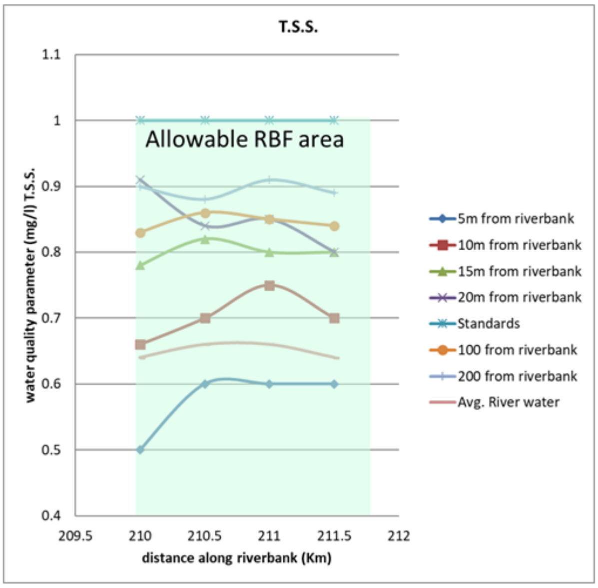
- The green area indicates the strip for reliable water quality results, where RBF is applicable within the area between the x-axis and the curve plotted for the "20 m apart from riverbank" results.
- The blue line indicates the Iraqi's acceptable value standards.

Based on the figures analysis, apparent was that:

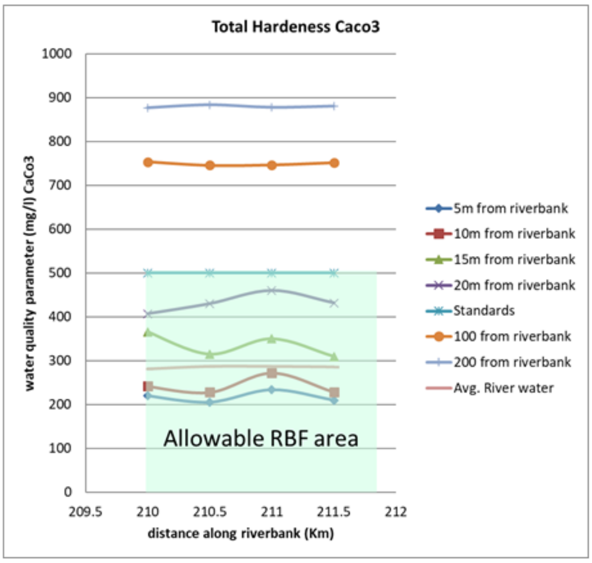
- The ***near-wells*** water quality parameters were within the permissible values of the Iraqi standards.
- This indicated that RBF could be applied within the shaded strip (i.e. between the ***near-wells*** curves of 5 to 20 m, away from Tigris Bank).
- The ***far-wells*** water quality was not compatible with the Iraqi standards.
- This designated that the ***far-wells*** water quality is not suitable for drinking, as many dangerous elements were higher than the allowable limits and the taste was nasty with water hardness more than allowable limit.
- ***Tigris River*** water quality was not suitable for drinking.
- This flagged out that many elements are beyond the permissible limit with unpleasant taste and high water hardness.



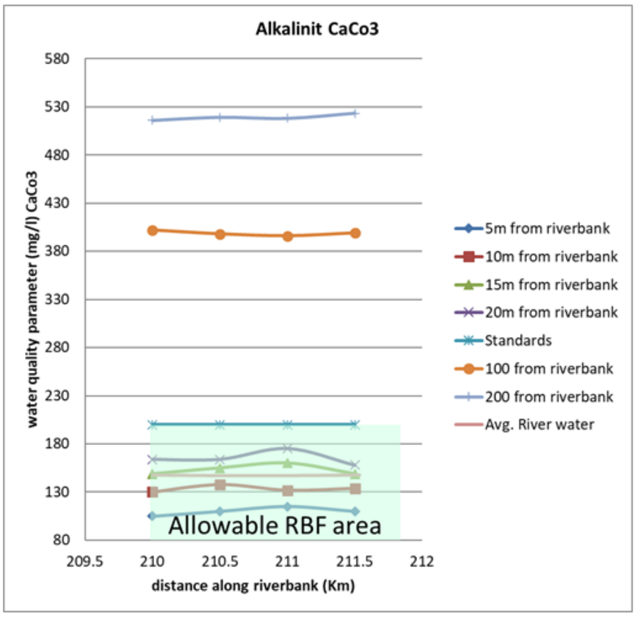
Graph 1: Verifying RBF applicability, in terms of EC



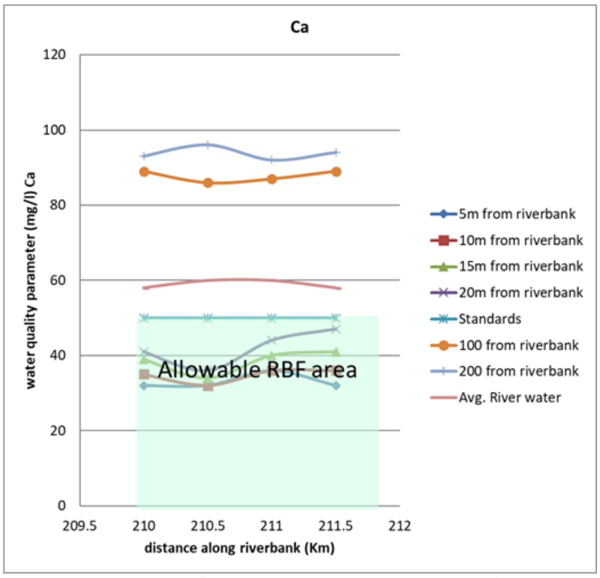
Graph 2: Verifying RBF applicability, in terms of TSS



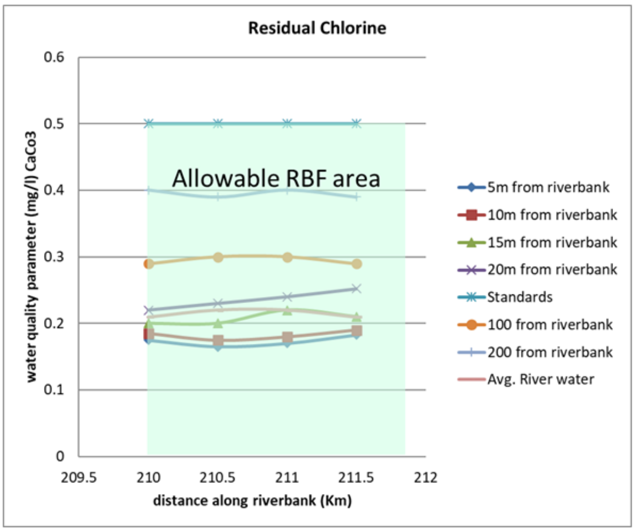
Graph 3: Verifying RBF applicability, in terms of CaCo3



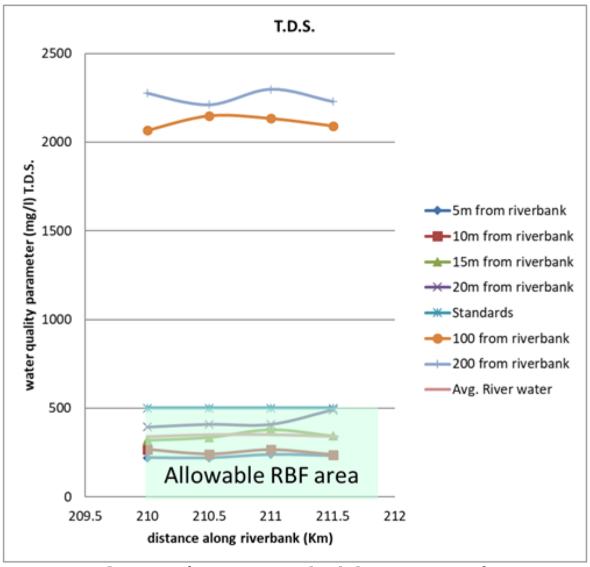
Graph 6: Verifying RBF applicability, in terms of Akalinity



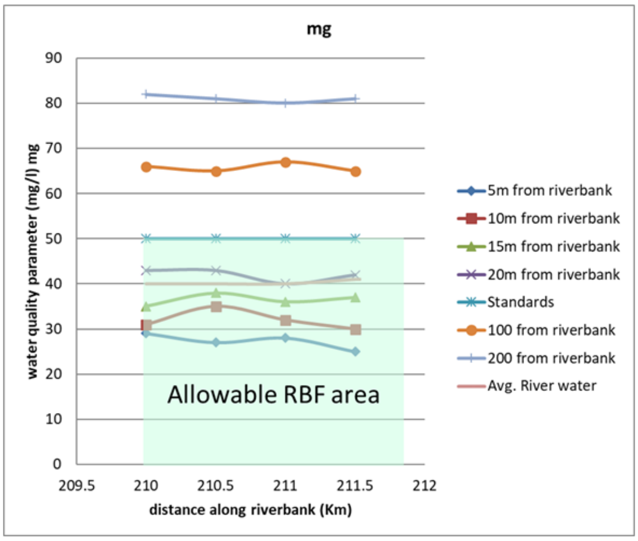
Graph 4: Verifying RBF applicability, in terms of Ca



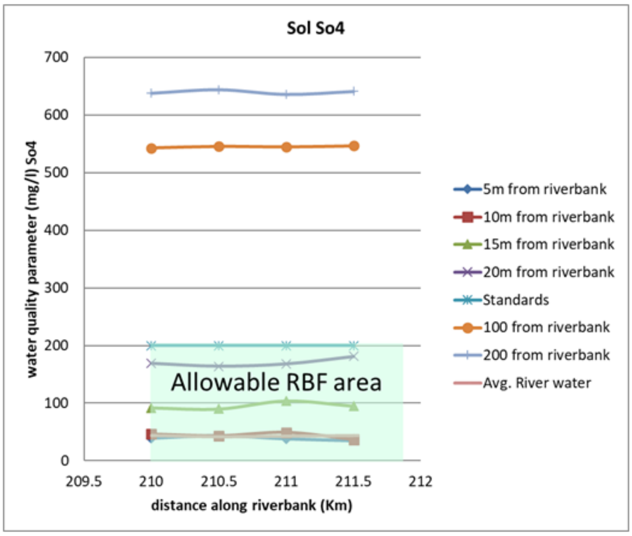
Graph 7: Verifying RBF applicability, in terms of Residual Chlorine



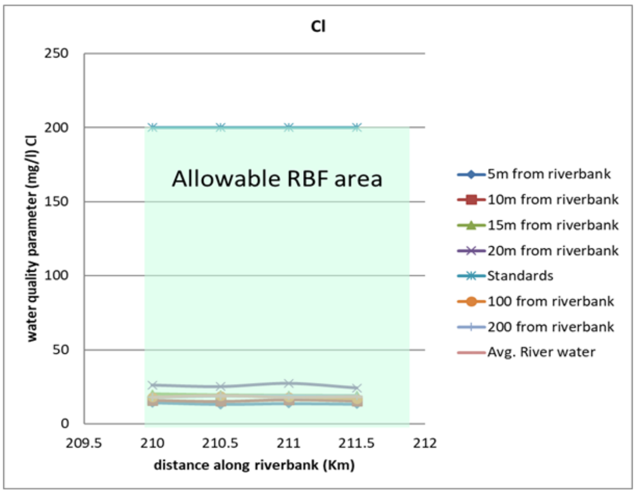
Graph 5: Verifying RBF applicability, in terms of TDS



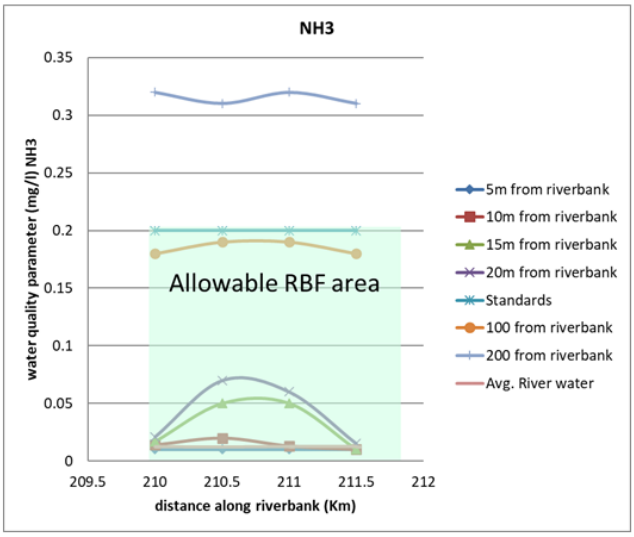
Graph 8: Verifying RBF applicability, in terms of Mg



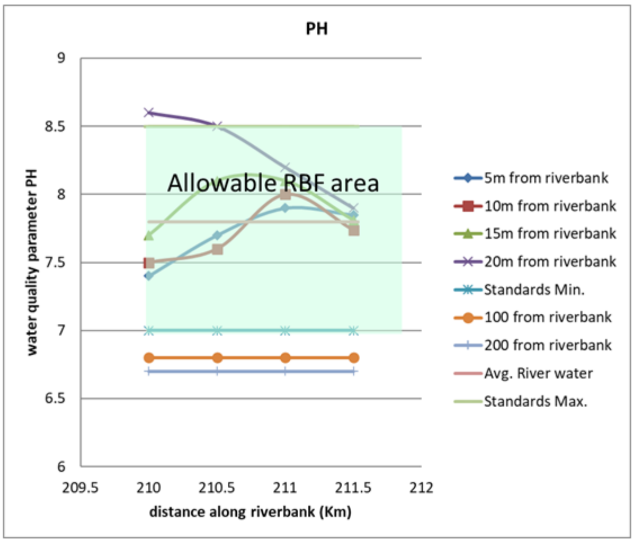
Graph 9: Verifying RBF applicability, in terms of SolSo4



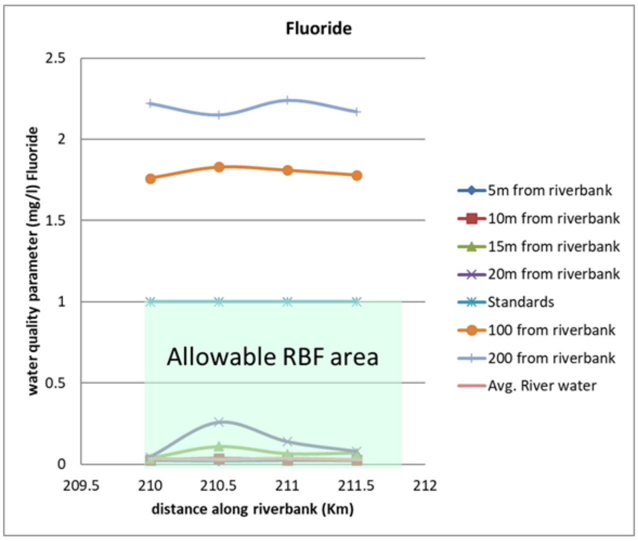
Graph 12: Verifying RBF applicability, in terms of Cl



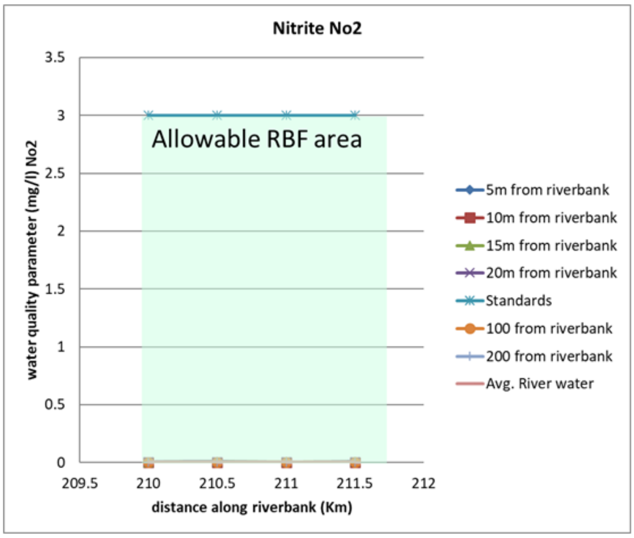
Graph 10: Verifying RBF applicability, in terms of NH3



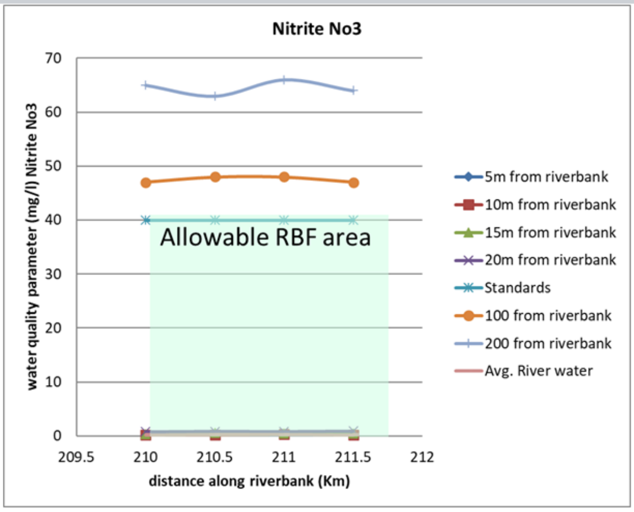
Graph 13: Verifying RBF applicability, in terms of pH



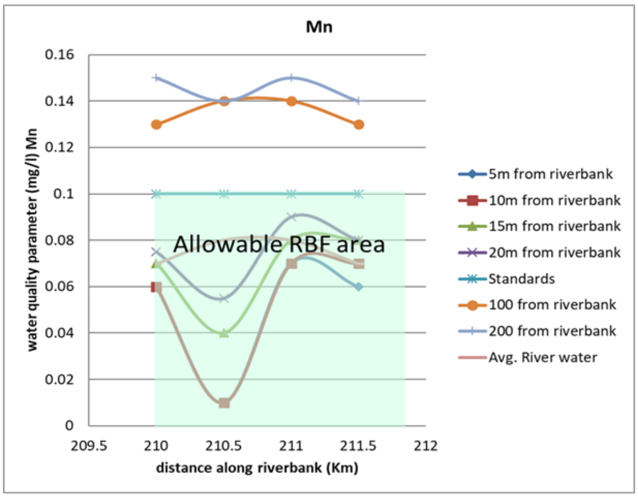
Graph 11: Verifying RBF applicability, in terms of Fluoride



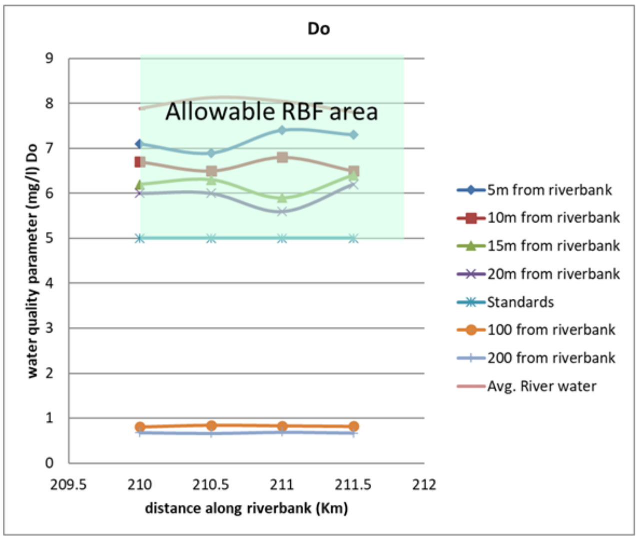
Graph 14: Verifying RBF applicability, in terms of No2



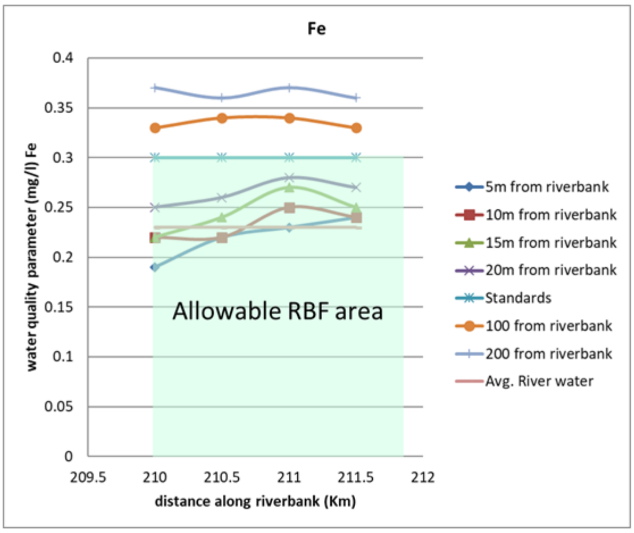
Graph 15: Verifying RBF applicability, in terms of No3



Graph 16: Verifying RBF applicability, in terms of Mn



Graph 17: Verifying RBF applicability, in terms of DO



Graph 18: Verifying RBF applicability, in terms of Fe

8. Conclusion and Recommendation

Based on the present investigation, apparent was the following:

- Based on the results, obvious was that all the extracted samples from the ***near-wells*** were within the Iraqi's Standards and does not need any treatment.
- All the extracted samples from the ***far-wells*** were beyond Iraqi's Standards, which indicates that groundwater is not feasible and needs to be treated.
- All the extracted samples from ***Tigris River*** were outside Iraqi's Standards, which indicates that groundwater is not feasible and needs treatment.
- The research results highlighted that RBF applicability in Iraq was verified.

Based on the conclusions of the present investigation, the suggested recommendations were as follows:

- There is a necessity of implementing the RBF technique to overcome Iraqi's water conflict crisis, where the vast sampling campaigns emphasized that RBF is a promising economic technique to Iraq Engineering practice.
- There is a significance to validate the innovative technique applicability against international standards.

8.1 Mechanical Properties of GFRP bars and steel fibers

The GFRP bars were locally manufactured using resin and glass fiber roving. Plastic molds with were created at a specific workshop for manufacture. As illustrated in Fig. 1, the ribbed bars have a diameter of 10, 12 mm.

The tensile strength and mechanical characteristics of GFRP bars were experimentally investigated. To improve the bond between the GFRP bars and the concrete, the outside surface of the bars was deformed. The mechanical characteristics of GFRP bars are illustrated here in Table 1.

REFERENCES

[1] Tufenkji, N., Ryan, J.N., Elimelech, M. "The promise of bank filtration" Environ. Sci. Technol (2002): 36 (21), 422A-428A.

[2] Kuehn, W., Mueller, U. "Riverbank filtration-An overview". J. Am. Water Works (2000).

[3] Sacher, F., Brauch, H.J. "Experiences on the fate of organic micro-pollutants during riverbank filtration" (2002): In: Ray, C. (Ed.), Riverbank filtration: understanding contaminant biogeochemistry and pathogen removal. Kluwer, Dordrecht, pp. 135-151.

[4] Hiscock, K.M., Grischek, T. "Attenuation of groundwater pollution by bank filtration" (2002): J. Hydrol. 266 (3-4), 139-144.

[5] Hoehn, E., Meylan, B. "Measures to protect drinking-water wells near rivers from hydraulic engineering operations in peri-alpine flood-plains" (2009): Grundwasser 14 (4), 255263.

[6] Brunner, P., Cook, P.G., Simmons, C.T. "Hydrogeologic controls on disconnection between surface water and groundwater" (2009): Water Resource. 45, 13.

[7] Huggenberger, P., Hoehn, E., Beschta, R., Woessner, W. "Abiotic aspects of channels and floodplains in riparian ecology" (1998): Freshwater Biol. 40 (3), 407-425.

[8] Eckert, P., Irmscher, R. "Over 130 years of experience with Riverbank filtration in Dusseldorf, Germany" (2006): J. Water Supply Res. T. 55 (4), 283-291.