REUSE OF TREATED SANITARY SEWAGE IN NAJAF CITY FOR AGRICULTURAL PURPOSES

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ABSTRACT

Sanitary sewage treatment plants can be considered as a source for water that can be used for different purposes. The agricultural sector is a steady and very big potential consumer of reclaimed water . so , treated sewage reusing in agricultural purpose is a good goal where it requires simpler treatment in comparison with other purposes

In this study , the quality of treated sewage in Najaf sewage treatment plant have been evaluated and compared with standard specifications of America, Egypt and Iraq water quality that used for agricultural purposes.

The evaluation process includes samples collection from effluent of treatment plant for a period of (12) months from January 2009 to January 2010. Then measuring the quality of treated sewage which includes measurement of Biochemical Oxygen Demand (BOD), Suspended Solid (S.S) ,Total Dissolved Solid (TDS), and PH .Also concentration of chemical elements which may cause harmful effect on plants like Cl,

Based on the results of this study it was found that: (1) Biochemical Oxygen Demand, Suspended solid , Total Dissolved Solid and PH values of effluent treated sewage of all date of measurement are within the maximum allowable range according to the Egyptian Standards and American Standards. (2) the concentrations of values of chlorine (Cl),sulphate (SO_4), Phosphate (PO_4), Sodium (Na) and Calcium(Ca) are :83%, 75%, 100%, 75%, 92% respectively are less than the Egyptian allowable rang while 75% of magnesium (Mg) values are exceeding the allowable limit. (3) TDS, PH, PO_4, NO_3 and Ca values of effluent treated sewage of all data of measurement are within the Iraqi allowable range. (4) The concentration values of BOD, S.S, Na and Mg are 58%, 75%, 75% and 1% respectively are less than the Iraqi allowable range. (5) no sodicity problem in the soil as a result of the use of treated water effluent from Najaf sewage treatment plant.

Key words: Sewage , Agricultural , Wastewater , Treatment , BOD , Najaf

إعادة استعمال مياه الصرف الصحي المعالجة في محطة معالجة المياه الثقيلة في مدينة النجف للإغراض الزراعية

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المستخلص :

يمكن اعتبار مياه الصرف الصحي مصدرا للمياه التي يمكن استخدامها للأغراض المختلفة . القطاع الزراعي هو المستهلك الكبير للمياه المستصلحة , لذلك إعادة استخدام مياه الصرف الصحي المعالجة للأغراض الزراعية هو هدف جيد حيث يتطلب معالجة بسيطة قياسيا بالمعالجات المطلوبة للإغراض الأخرى .

في هذه الدراسة تم تقييم المياه المعالجة في محطة النجف ومقارنتها بالمواصفات القياسية المستخدمة للأغراض الزراعية حيث تم مقارنتها بالمواصفات المصرية والأمريكية والعراقية .

عملية التقييم تتضمن جمع العينات من المياه المعالجة الخارجة من محطة النجف لفترة (12) شهرا من كانون الثاني 2009م إلى كانون الثاني 2010م ومن ثم تم قياس نوعية المياه المعالجة والتي تشمل المتطلب الحيوي للأوكسجين , المواد العالقة , المواد الذائبة الكلية , الأس الهيدروجيني وقياس تركيز بعض العناصر الكيمياوية التي لها تاثيرات ضارة على النباتات مثل الكلور .

اعتمادا على نتائج هذه الدراسة يمكن استنتاج 1- قيم المتطلب الحيوي للأوكسجين , المواد العالقة , المواد الذائبة الكلية والأس الهدروجيني للمياه المعالجة الخارجة من المحطة ولكل القياسات هي ضمن الحدود المسموحة حسب المواصفات المصرية والأمريكية . 2- قيم تراكيز (الكلور , الكبريتات , الفوسفات , الصوديوم والكالسيوم) هي 83% ، 75% ، 100% ، 75% ، 92% على التوالي اقل من الحدود المصرية المسموحة بينما 75% من قيم المغنيسيوم تتجاوز الحد الاعلى. 3- قيم الاملاح الذائبة الكلية، الاس الهيدروجيني، الفوسفات، النترات والكالسيوم للمياه المعالجة الخارجة من المحطة ولكل القياسات هي ضمن الحدود المسموحة حسب المواصفة العراقية. 4- قيم تراكيز المتطلب الحيوي للاوكسجين، المواد العالقة، الصوديوم والمغنيسيوم هي 58% ، 75% ، 75% ، 1% على التوالي اقل من الحدود العراقية المسموحة. 5- لا توجد مشكلة صودية في التربة نتيجة استخدام المياه المعالجة الخارجة من محطة معالجة مياه الصرف الصحي في النجف.

NOMENCLATURE

BOD_5	Biochemical Oxygen Demand
S.S	Suspended Solids
TDS	Total Dissolved solids
Mg/l	Milligrams per liter
SAR	Sodium adsorption ratio
Ca	Calcium
Na	Sodium
Mg	Magnesium
NSTP	Najaf Sewage Treatment Plant
ds/m	Decisiemens per metre

INTRODUCTION

Water is an important element of the three environment elements (air ,water, soil) because it being directly linked to the lives of living organisms . It is known that water covers more than three-quarters of the globe, but despite all this, good for use remains slightly with the increasing need for it . In later times the world know water crisis ,as a result of waste water and poor distribution of this wealth in addition to the climatic conditions that helped to exacerbate this crisis and its spread (Abdul Alla , 2010).

Water –related problems are increasingly recognized as one of the most immediate and serious environmental threats to human kind water use has more than tripled globally since 1950,and one out of every six persons does not have regular access to safe drinking water. Lack of access to a safe water supply and sanitation affects the health of 1.2 billion people annually(WHO and UNICEF,2000) .The latest Global Environment Outlook of the United Nations Environmental Programme(UNEP)reports that about one third of the worlds populations currently live in countries suffering from moderate to high water stress, where water consumption is more than 10%of renewable fresh water resources (UNEP,2002a)

Faced with these challenges ,there is an urgent need to improve the efficiency of water consumption ,and to augment the existing source of water with more sustainable alternatives .Numerous approaches ,modern and traditional ,exist throughout the world for efficiency improvements and augmentation .Among such approaches, wastewater reuse has become increasingly important in water resource management for both environmental and economic reasons. Wastewater reuse has a long history of applications, primarily in agriculture, and additional areas of applications ,including industrial household and urban are becoming more prevalent Of them all, wastewater reuse for agriculture still represents the large reuse volume ,and this is expected to increase further particularly in developing countries(UNEP,2002a)

The most common reasons for establishing a wastewater reuse program is to identify new water sources for increased water demand and to find economical ways to meet increasingly more stringent discharge standards(caigan,2005).

The main objective of this study is to evaluate the quality of treated sewage in Najaf Treatment plant and then to study the possibility of treated sewage reuse for agricultural in Najaf city.

THE GOALS OF REUSE A WASTE WATER

The use of treated sewage for agriculture purposes is an important goal because of :

1- population growth and the subsequent growing demand for food production leads to increased demand for irrigation water(on a global scale irrigation water represents about 70%of the total water demand)and in some countries reaches up to 85%. Therefore ,the agricultural sector is a steady and very big potential consumer of reclaimed water.

2- The presence of nutrients in the wastewater offers an additional benefit ,although often overestimated when compared to the importance of the water presence

3- The large water quantities needed in combination with the fairly uniform quality standards required, favor agricultural reuse projects connected to centralized wastewater treatment facilities, which are often located in the vicinity of the irrigated areas.

4- The required quality characteristics of the reclaimed water for irrigation can be achieved through reasonable treatment ,which can vary depending on the method of irrigation and the adoption of additional measures. Often this treatment is provided irrespectively of irrigation, in compliance with effluent discharge regulations .The need for additional treatment may arise for certain irrigation practices , but even in these cases the associated costs can be reasonable

5- During irrigation soil offers additional treatment , by removing pollutants , which would otherwise end up in surface water or the ground water.
The quality of treated sewage used in agriculture has a great influence on the operation and performance of sewage treatment plants .Generally , the required quality of effluent is depended on the crops to be irrigated , the soil conditions and the adopted system of effluent distribution(Alya ,2008)

THE AREA STUDY

Najaf sewage treatment plant is located in Albrakia region , which lies about (3) kilometers from the center of kufa city . The project serves 25%of the population , but with enough space to allow future expansion to secure the city's needs for the future. The location of the study area is shown in **Figure. (1).**

Najaf city is a holy city , therefore is expected to host many visitors on religious occasions and it was chosen as the capital of Islamic culture for the year 2012, so it is very important to ensure the viability of a project to receive this extra load .

NSTP(Najaf Sewage Treatment plant) is designed to receive load of 140000 citizens and the characteristics of final flow to be (20mg/l) of BOD and (30mg/l) of S.S. the highest rate of flow is 27000m^3/day.

Wastewater in many parts of Najaf city is pumped through the network by the pumping stations to the project which contains preliminary , primary and secondary treatment in addition to chlorination and treatment of sludge.

Because of temperature rise in the countries of the Middle East , including Iraq , sewage are in the case of sepsis and gases cause buoyancy minutes sludge in the primary treatment , thus reducing the level of performance in this treatment.

Secondary treatment is done through the membranes by the natural ventilation of the biological filters (Trickling Filters). Through the work of biological filters bacteria grow on pollutants found in wastewater but remains constant in number to support filter filling . Bacteria get the air from the atmosphere as a result of temperature difference between the sludge and air , which leads to airflow within filter charges .

Bectel Company has improved the effectiveness of secondary treatment to improve the quality of effluent treatment plant through the program of Iraq reconstruction.

Chlorination process has been shut down because of that the addition of chlorine to water containing organic material cause cancer.

There are two sources of surplus sludge in Najaf station: excess sludge of the aeration tank resulting from the growth of bacteria and the quantity of sludge deposited in the initial tank . Then sludge is pumped to thickener tank and then to drying beds that are built entirely of concrete and when dry will be raised and removed permanently . The flow chart of the NSTP is shown **Figure(2)**

Finally , the treated effluent water is disposaled to Shatt al-Kufa , but within the specifications set out in **Table(1)** (Palmer, 2004)

STANDARDS OF IRRIGTION WATER

- Accordıng to the Egyptian water qualıty for agrıcultre use ın Egypt. These specıfıcatıon of water Irrıgatıon were classıfıed ın **Table (2) and (3)**
- According to Standard specification of American Water quality for agriculture. These specification were classified in **Table(4).**

RESULTS AND DISCUSSION

In this study the evaluation and visibility results of using the treated sewage in NSTP for agricultural purposes are presented . Tow aspects were considered in the evaluation process . These aspects include the quality of treated sewage and concentration of chemical elements.

Evaluating the Quality of Raw Sewage.

The quality of raw sewage was evaluated based on sewage samples drawn from the effluent of NSTP . The parameters used to define the quality of raw sewage are Biochemical Oxygen Demand(BOD5) , Suspended Solid(S.S), Total Dissolved solids(TDS) and (PH) . The obtained results are as shown in **Table(6)** . The results were compared with relevant standards of sewage use for agricultural purposes . To satisfy this goal , the Egyptian Standards(ECP 501-2005)and American Standards were used . The data collection program was extended over a period of twelve months from January 2009 to January 2010. **Figures (3) , (4) , (5) and (6)** show the histogram of the variation of the measured parameters over the sampling time. The upper and the lower values of standard parameters as suggested by the Egyptian code were dully superimposed. The upper limit represents type (c) of treated sewage which is suitable only for wooden trees plantation , while the lower limit represents type (A) of treated sewage which can be used to irrigate peeled fruit and sport field.

The data given in **Table(6)**were compared with Egyptian standards and American standards .The results of comparison in effluent of NSTP given **Figures (3),(4),(5) and(6).**In these figures ,it can be noticed that:-

1-BOD5 Values of effluent treated sewage of all data of measurement are within the maximum allowable range **Figure(3).**50% of BOD5 effluent within type (A)of treated sewage which can be used to irrigate peeled fruit and sport field.25% of BOD5 effluent within type(B)of treated sewage which can be used to irrigate Fodder crops, fruit produced for packaging such as (lemon , mango and olive) and fiber crops such as flax

The remaining of BOD5 effluent within the type(c)of treated sewage which can be used to irrigate wooden trees plantation.

2-S.S values of effluent treated sewage of all data of measurement are within the maximum allowable range **Figure(4**) 8% of S.S effluent within type(A)75% of S.S effluent within type(B) and 17%of S.S effluent within type(C)

3-TDS values of effluent treated sewage of all data of measurement are within the maximum allowable limit **Figure(5)**

4-pH values of effluent treated sewage of all data of measurement are within the maximum allowable limit **Figure(6)**

Chemical Elements

The chemical elements of raw sewage in NSTP were evaluated based on their concentration in treated sewage in the effluent of the plant. These elements include :Chlorine(Cl), Sulphate(SO4), Phosphate (PO4),Nitrate(NO3) Sodium(Na),Magnesium(Mg)and Calcium(Ca)

The collected data regarding concentration of chemical element of treated sewage effluent are shown in **Table(7)** Data collection program was extended over a period of twelve months(from January 2009 to January 2010).These data were compared with the Egyptian standards .The results of comparison are as given in **Figures(7),(8),(9),(10), (11) ,(12) and(13**)in this figures it can be noticed that:-

1- The obtained values of chlorine concentration at different time are as shown in **Figure(7)** . These values were compared with the maximum allowed concentration in sewage using for agricultural purposes which is (400 mg/l) , so as shown in this figure (83%) of the values are less than the allowable.
2- The obtained values of sulphate concentration at different time are as shown in **Figure(8).** These values were compared with the maximum allowed concentration in sewage using for agricultural purposes which is (500mg/l) , so as shown in this figure (75%) of the values are less than the allowable.
3- The obtained values of (PO4) concentration at different time are as shown in **Figure(9) .** These values were compared with the maximum allowed concentration in sewage using for agricultural purposes which is (30 mg/l) , so as shown in this figure all of the values are less than the allowable , therefore , the treated sewage quality is allowed for agriculture.
4- The obtained values of Nitrate concentration at different time are as shown in **Figure(10**)

5- The obtained values of sodium concentration at different time are as shown in **Figure(11).** These values were compared with the maximum allowed concentration in sewage using for agricultural purposes which is (230mg/l) , so as shown in this figure (75%) of the values are less than the allowable.
6- The obtained values of Magnesium concentration at different time are as shown in **Figure(12)** . These values were compared with the maximum allowed concentration in sewage using for agriculture purpose which is (100mg/l) , so as shown in this figure (75 %) of the values are exceeding the maximum allowable limit .
7- The obtained values of Calcium concentration at different time are as shown in **Figure (13) .** These values were compared with the maximum allowed concentration in sewage using for agricultural purposes which is (230mg/l) , so as shown in this figure (92%) of the values are less than allowable.

The data also were compared with Iraqi standards. The results of comparison are:
58% of BOD values are within the Iraqi standards.
75% of S.S values are within the Iraqi standards.
100% of TDS values are within the Iraqi standards.
100% of PH values are within the Iraqi standards.
100% of PO4 values are within the Iraqi standards.
100% of NO3 values are within the Iraqi standards.
75% of Na values are within the Iraqi standards.
1% of Mg values are within the Iraqi standards.
100% of Ca values are within the Iraqi standards.

Sodicity problem

Rhoades method (Rhoades, 1977) was adopted to predict soil permeability and structural stability for soil by comparison of Sodium adsorption ratio percentage and EC combinations . the values of SAR and EC of treated sewage in NSTP were measured over all study period (from Jan. 2009 to Jan.2010),the obtained results are shown in **Table (8)** . in **Figure (14**) Rhoades method was applied to predict soil permeability from using treated sewage for agricultural , since all of the values fall to the right of the critical line , the wastewater for all months were not expected to cause loss of soil permeability.

CONCLUSIONS

Based on the results of this study the following conclusions can be drawn.

1. BOD5 , S.S , TDS and PH values of effluent treated sewage of all data of measurement are within the maximum allowable range . Therefore this treated sewage can be used for agricultural purposes to irrigate some crops such as :

crop	Limitation	
	BOD(mg\l)	S.S(mg\l)
Shade trees	Less than 20	Less than 20
Fodder crops	Less than 60	Less than 50
flax	Less than 60	Less than 50
camphor	Less than 400	Less than 250
castor	Less than 400	Less than 250

2. The concentration values of Cl , SO4 , PO4 , Na , Mg and Ca are :
- 83% of Cl values are less than the allowable
- 75% of SO4 values are less than the allowable
- 100% of PO4 values are within the allowable
- 75% Na values are less than the allowable
- 92% of Ca values are less than the allowable
- 75 of Mg values are exceeding the maximum allowable limit
3. TDS, PH, PO4, NO3 and Ca values of effluent treated sewage of all data of measurement are within the Iraqi allowable range.
4. The concentration values of BOD, S.S, Na, and Mg are:
   58% of BOD values are less than the allowable.
   75% of SS values are less than the allowable.
   75% of Na values are less than the allowable.
   1% of Mg values are less than the allowable.
5. sometimes , the specification of the water effluent from the treatment plant is higher than the environmental limits allowed to throw in the river but within the limits and specifications of water used for agricultural purposes in that case better to use this water for agricultural to provide water and to preservate the characteristics of the river on the other hand
6. No sodicity problem in the soil as a result of the use of treated water effluent from Najaf sewage treatment plant according to application of Rhoades method.

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Table(1) Specification of Effluent Water of NSTP Allowed to Disposal in Shatt Al-Kufa

parameter	Limit
Biochemical oxygen Demand BOD	< 40 mg/l
Suspended solids S.S	mg/l < 60
Chemical oxygen Demand COD	< 100 mg /l
PO4	< 3mg/l
NO3	<50mg/l

Table (2) wastewater Standards for Agrıcultural Irrıgatıon ın Egypt . (salah Aldeen,2005)

Level of treatment / parameter		*Level A	**Level B	***Level c
Max.physical and chemical characteristic for the effluent	BOD (mg/l)[1]	<20	<60	<400
	S.S (mg/l)	<20	<50	<250

1After Infiltration

* Level A is optimum level which can be reach by developing secondary unit to include Infiltration , Disinfection , etc . And because of high cost of this type of treatment , it used for special cases if it is needed

**Level B is secondary treatment which can be obtain from the established unit in Egyptian town and village , which used any one of the following ways according to Egyptian code in design and be forming units of wastewater treatment:

- Activated sludge.
- Oxidation Ditches.
- Trickling filters.
- Stabilization ponds.

***Level C is the treatment which the water quality result from screen and primary unit (sedimentation tank).

Table(3) Levels of chemical Elements for Wastewater Treatment and using for Agricultural Irrigation in Egypt.(Salah Aldeen,2005)

Element	Long term maximum concentration(mg/l)(1)	Short term maximum concentration(mg/l)(2)
Total PO4	_	30
Cl	_	400
SO4	_	500
Na	230	230
Mg	100	100
Ca	230	230

(1) Possibility of Continuous use of water and for all soil type.

(2) Possibility of use water for period reaches 20 years in fine soil either alkaline or neutral.

Table (4) Water Quality for Irrigation Purposes. (Najem, 1999)

Symbol	Limiting Value
PH	4.5 – 9.0
NO3	unknown
TDS	2000-5000 mg/l(tol.crops) 500-1000 mg/l (sans.crops)

Table (5) Wastewater Standards for Agricultural Irrigation in Iraq (Ministry of Environment, 2010)

Symbol	Limiting value Bilateral treatment
BOD	40
S.S	40
TDS	2500
PH	6-8
PO4	25
NO3	50
Ca	450
Mg	80
Na	250

Table (6) Quality of Effluent Raw Sewage in Najaf City Treatment Plant

Standard of Irrigtion Water	20 – 400* 40***	20 – 250* 40***	500 – 5000** 2500***	4.5 – 9** 6-8***
Concentrations / Date of measurement	BOD_5 mg/l	S.S mg/l	TDS mg/l	PH mg/l
Jan.	90"	36	2138	7.5
Feb.	77"	39	1811	7.6
Mar.	47.9"	39	1960	7.53
Apr.	55"	23	1775	7.4
May.	19	38	1780	7.54
Jun.	163"	54	1860	7.5
Jul.	4.3	48	2133	7.5
Aug.	8.4	26	2074	7.7
Sep.	5.21	40	1041	7.5
Oct.	20	29	1960	7.61
Nov.	18.93	69	1934	7.6
Dec.	16.7	4	1832	7.5
Average	43.787	37.083	1858.167	7.54

*Egyptian Standard Limits

**American Standard Limits

*** Iraqi standard limits.

"High concentration of BOD in the water effluent from the treatment Plant because of the excesses of some industrial Plants and hospitals to sewer

Table (7) Concentration of Chemical Element of Effluent Treated Sewage

Standard of Irrigation Water	400 mg/l	500 mg/l	30 mg/l 25**	Unknown 50**	230 mg/l 250**	100)mg/l(80**	230 mg/l 450**
Concentration of chemical elements / Date of measurement	Cl)mg/l(	SO4 ( ) mg/l	PO4)mg/l(	NO3	Na	Mg	Ca
Jan.	357.6	171.2	1.23	40.04	127.5	175.7	208
Feb.	342.9	200.3	1.507	7.3	448	475.8	240
Mar.	450.7	*710	1.88	16.2	160	292.8	160
Apr.	436	303.9	1.459	6.8	155	136.6	164.04
May.	303.7	350	0.765	9.923	175	100	165
Jun.	348.2	400	10.94	9.61	180	112	123
Jan.	362.5	450	4.90	10.50	270	178.1	132
Aug.	352	500	0.67	8.7	190.8	109.8	160
Sep.	347.88	440	0.27	8.7	376	75.6	168
Oct.	321.4	*900	1.55	16.43	220	148.8	156
Nov.	323.3	*850	.54	8.7	195	98	145
Dec.	317.4	450	1.56	10.80	200	104	165
Aver.	355.3	477.1	2.273	12.81	224.77	167.3	165.5

*High concentration of SO4 in the water effluent from the treatment plant because of the excesses of some industrial plants and hospital to sewer

** Iraqi standard limits.

Table (8): Monthly SAR and EC values of Effluent Treated Sewage in Najaf City Treatment Plant

Date of measurement	EC ds/m	SAR*
Jan.	3.341	9.2
Feb.	2.453	23.7
Mar.	3.063	10.6
Apr.	2.572	12.6
May.	2.781	15.2
Jun.	2.906	16.61
Jul.	3.333	21.7
Aug.	3.241	16.43
Sep.	1.627	34.07
Oct.	3.063	17.8
Nov.	3.022	17.69
Dec.	2.863	17.25

$$SAR = \frac{Na}{\sqrt{\frac{ca+mg}{2}}}$$

Figure(1) The Location of the Study Area

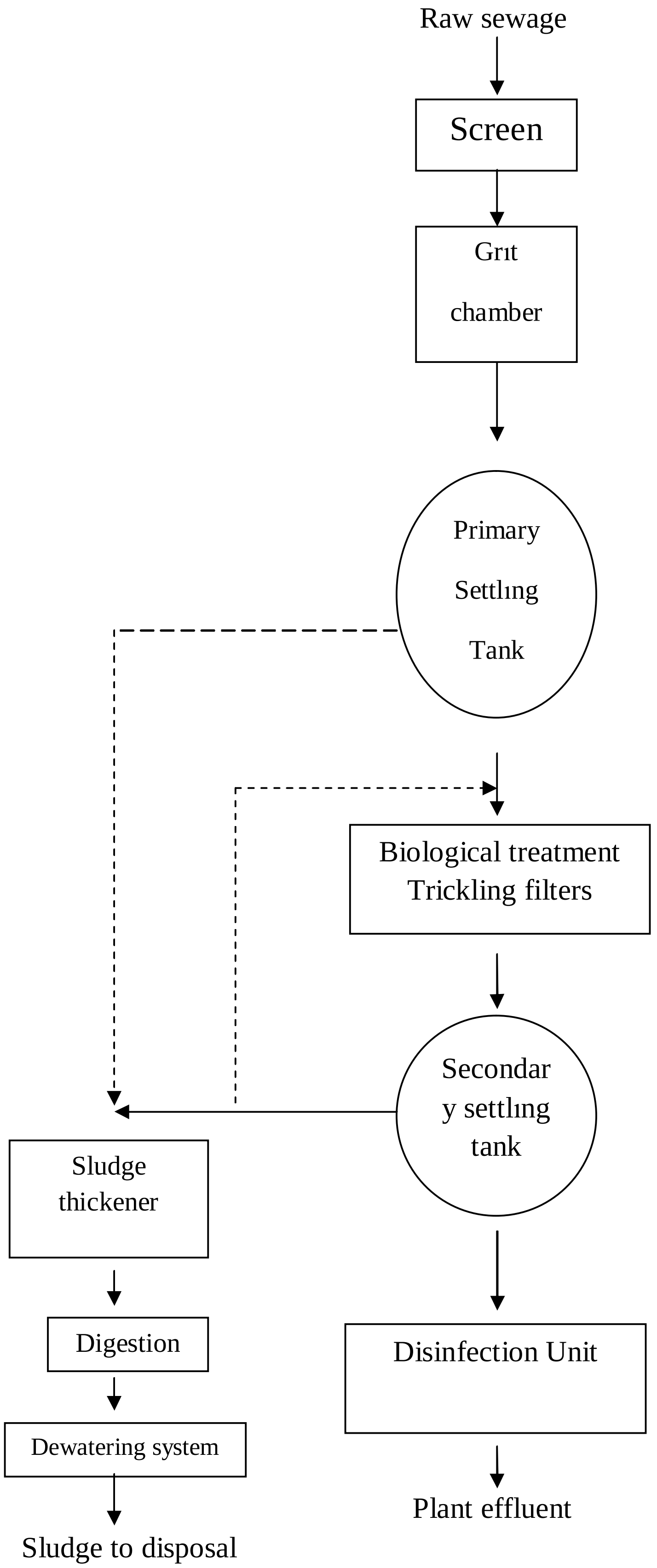

Figure (2) Flowchart of NSTP

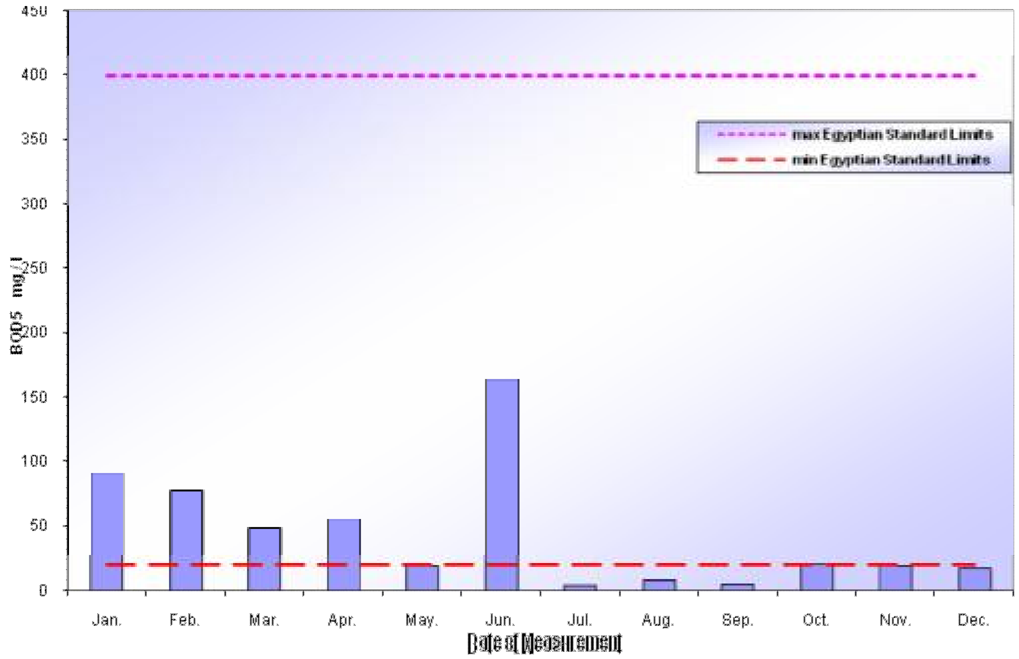

Figure (3) Comparison of Standard BOD5and Present BOD5 in Effluent of NSTP

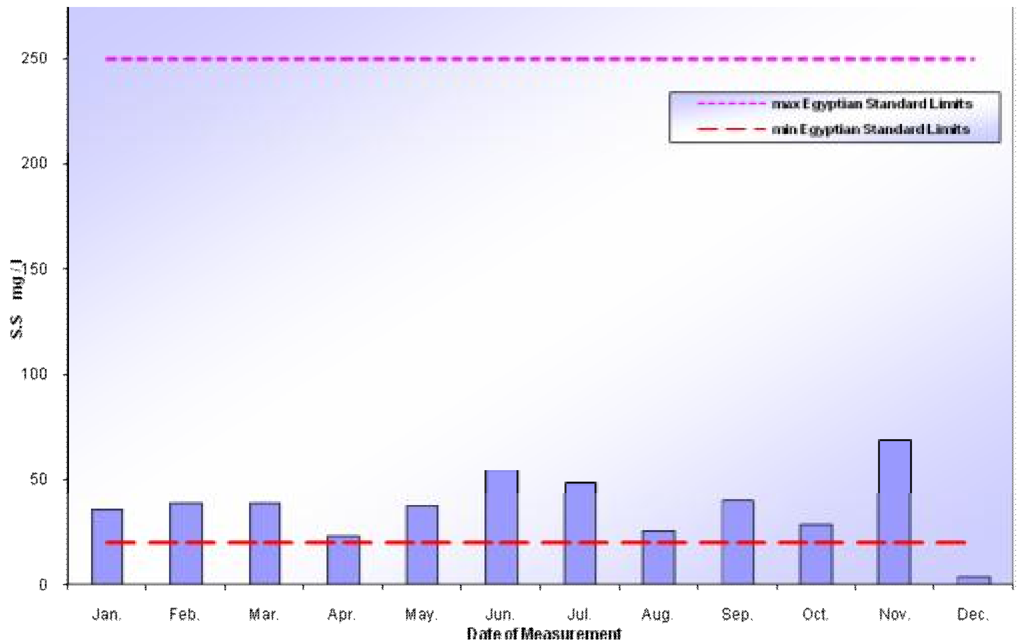

Figure (4) Comparison of Standard S.S and Present S.S in Effluent of NSTP

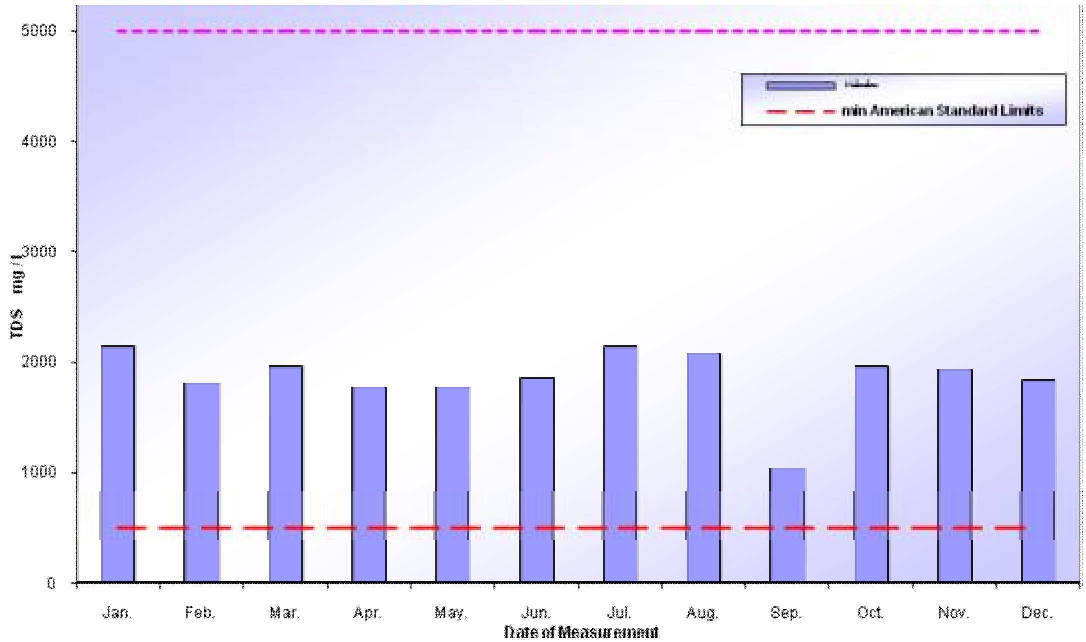

Figure (5) Comparison of Standard TDS and Present TDS in Effluent of NSTP

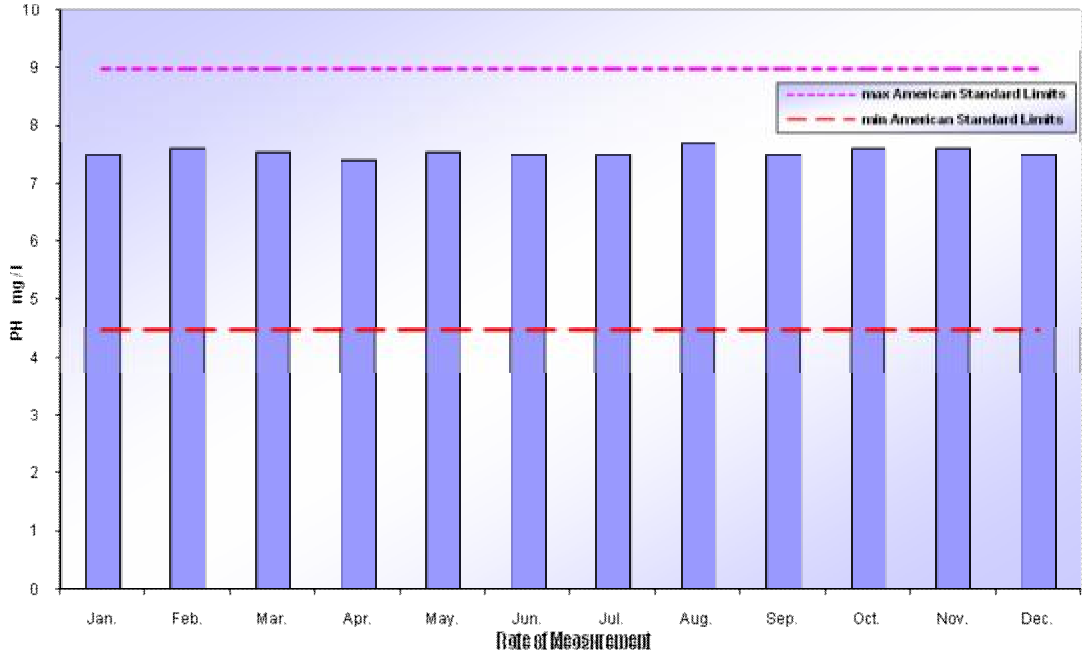

Figure (6) Comparison of Standard PH and Present PH in Effluent of NSTP

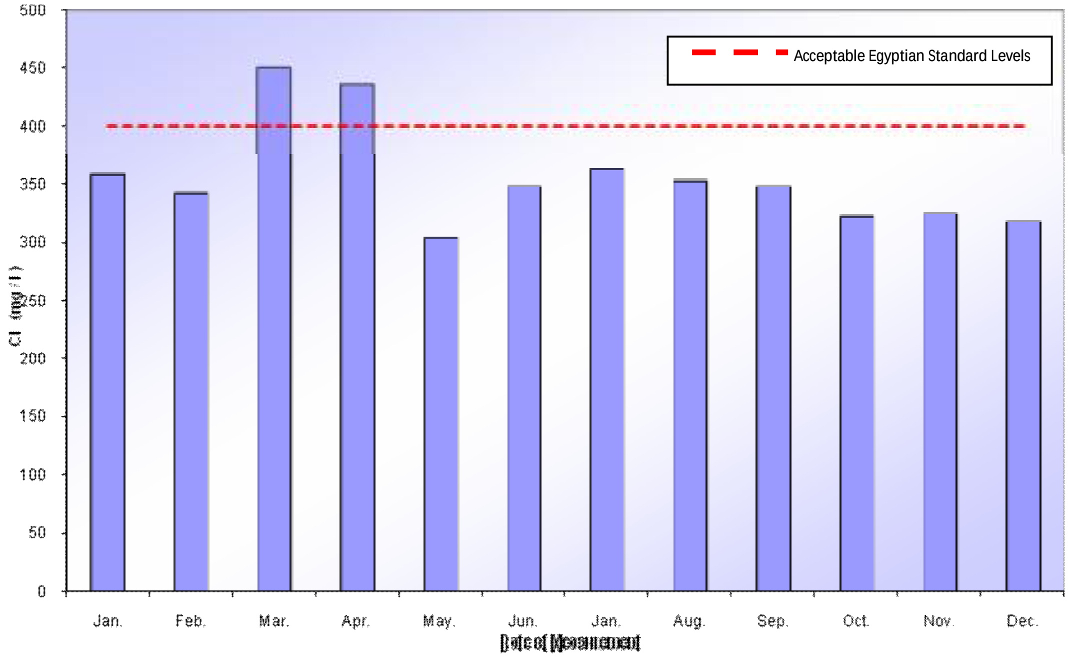

Figure (7) Comparison of Standard Concentration of CL and present Concentration of CL in Effluent of NSTP

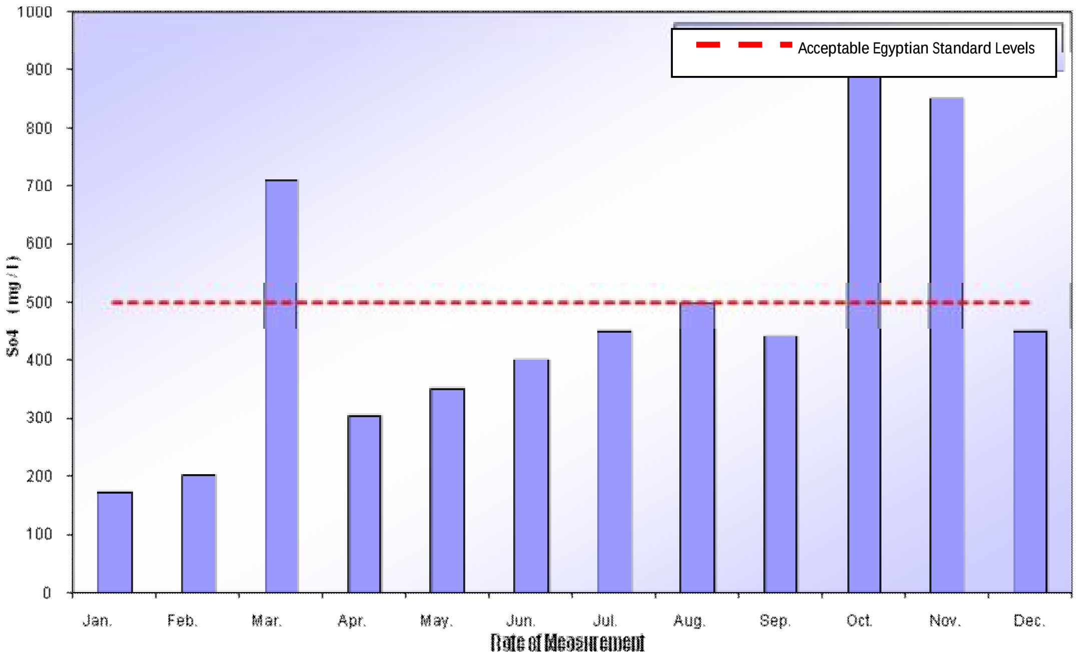

Figure (8) Comparison of Standard Concentration of SO4 and present Concentration of SO4 in Effluent of NSTP

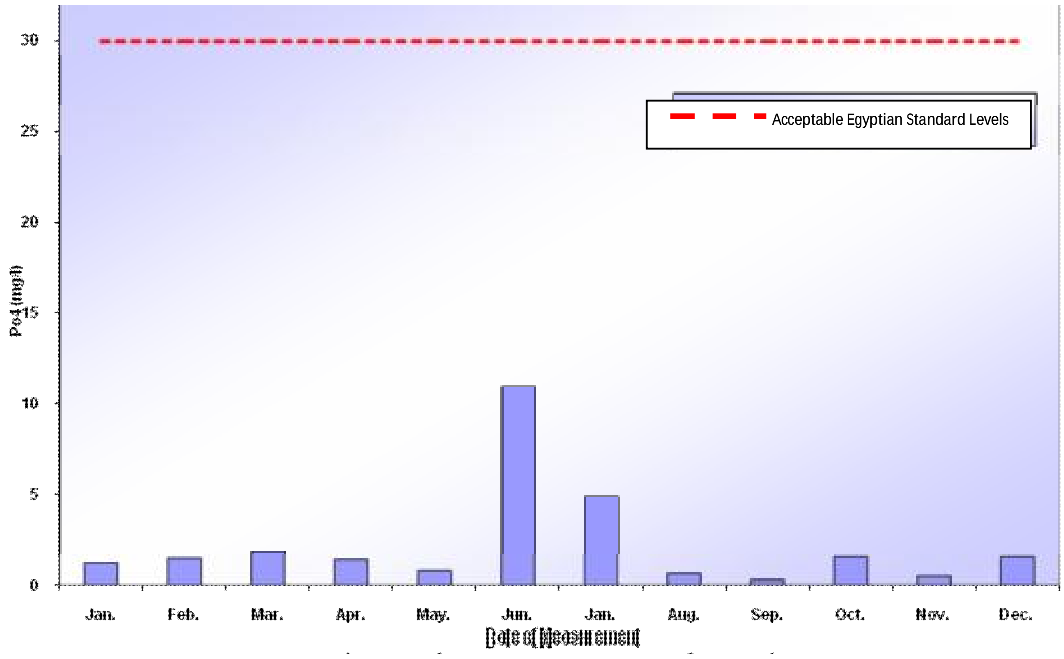

Figure (9) Comparison of Standard Concentration of PO4 and present Concentration of PO4 in Effluent of NSTP

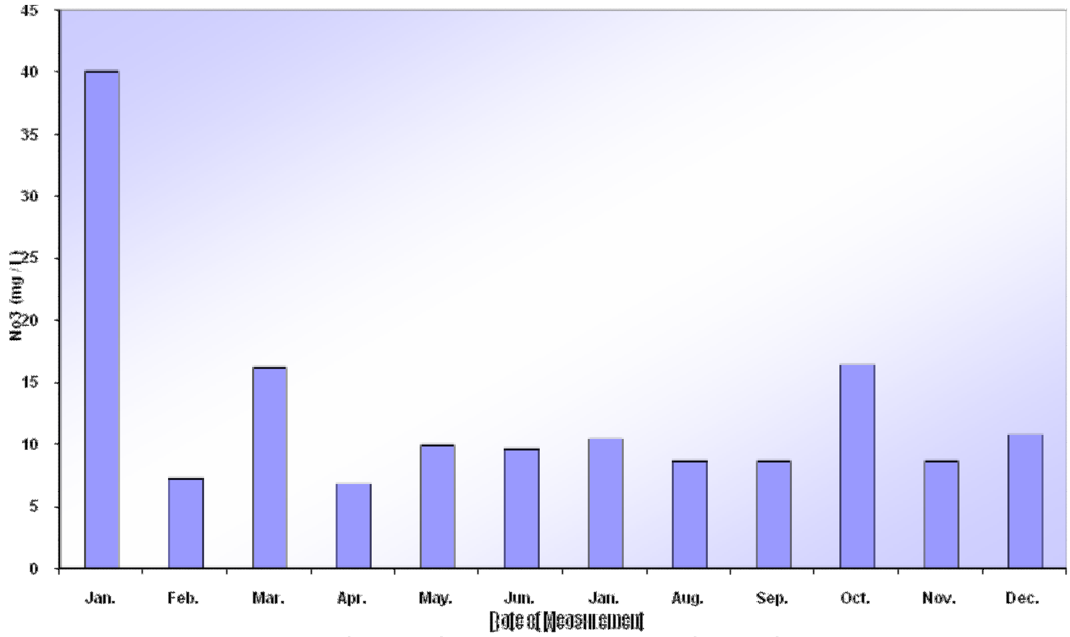

Figure (10) Comparison of Standard Concentration of NO3 and present Concentration of NO3 in Effluent of NSTP

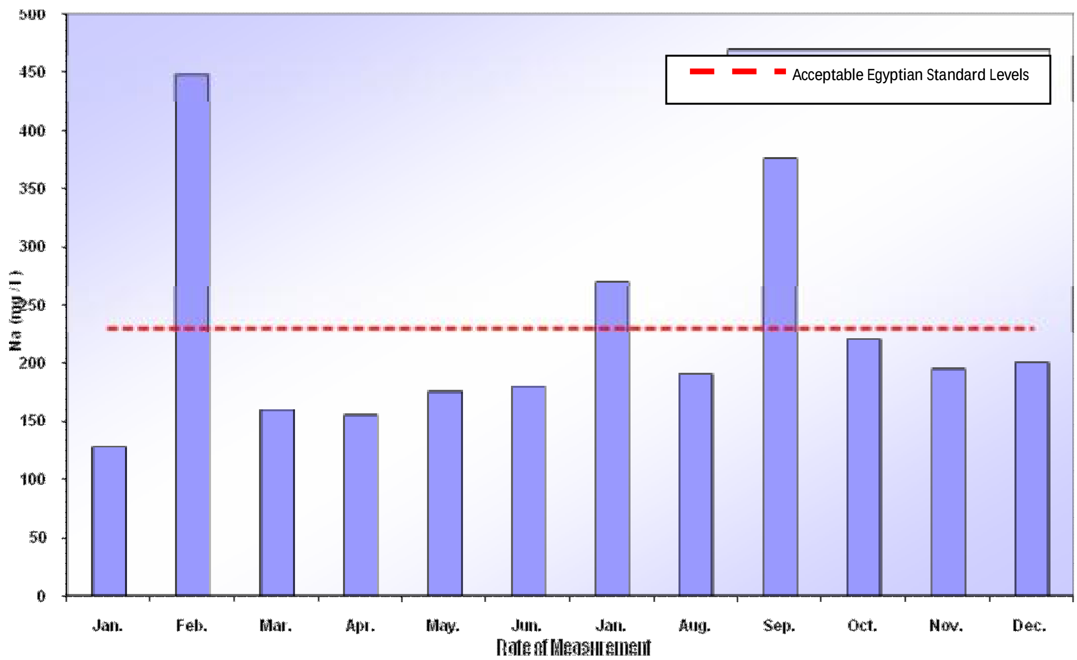

Figure (11) Comparison of Standard Concentration of Na and present Concentration of Na in Effluent of NSTP

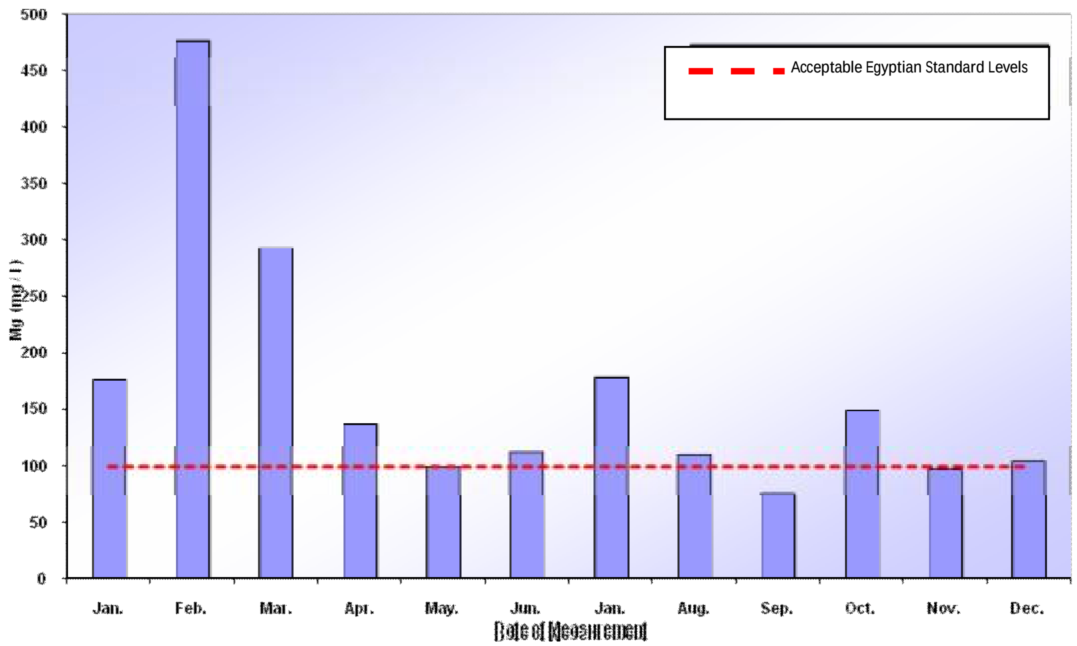

Figure (12) Comparison of Standard Concentration of Mg and present Concentration of Mg in Effluent of NSTP

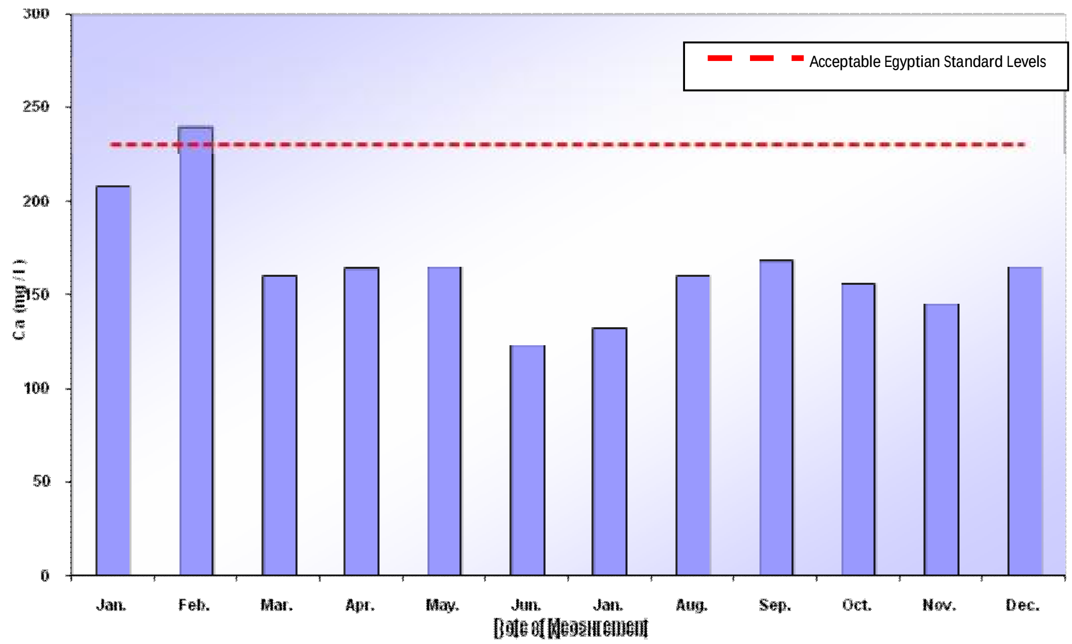

Figure (13) Comparison of Standard Concentration of Ca and present Concentration of Ca in Effluent of NSTP

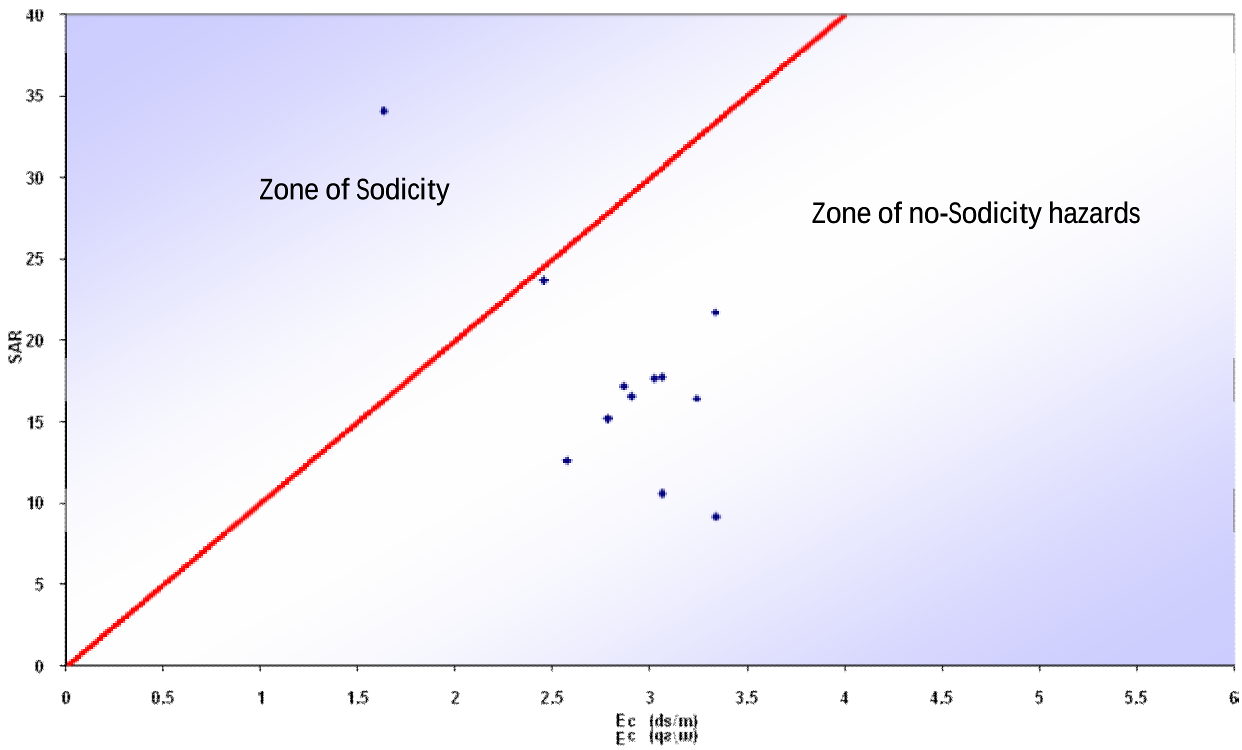

Figure (14) Comparison of SAR-EC Combinations Produced with Use of Effluent Treated Sewage in NSTP with those Associated with Adequate and Inadequate Soil Permeability