Sci. J. Fac. Sci. Minufiya Univ. Vol. XI (1997) 163 - 177

Well design criteria and potential encrustation of groundwater and their impact on the well yield, case study, Menufiya Governorate, Egypt

K.A.Dahab

Geol. Deprt. Fac. Scin. Menufiya Univ.

Abstract

The present study discusses the main reasons of well abandonment and well yield decreasing of the most drinking water stations in Menufiya Governorate. Field investigations of twenty drinking water stations was done and collection of groundwater samples from these stations was also carried out. Hydrochemical model named wateqp was applied to predict chemical composition and saturation states of water yielded by wells. The obtained results showed that poor well design which includes short screen lengths, very narrow screen slot openings and calcareous gravel pack materials is one of the main reasons of well abandonment. It was found also that the water yielded by wells is hard water (encrusting water) and it has pH-values greater than 7.5, carbonate hardness from 222 to 368 ppm, dissolved iron from 1.6 to 0.36 ppm, dissolved manganese from 1.2 to 0.61 ppm and silica from 17 to 11 ppm.

The obtained results of chemical activities of different ions and saturation states of relevant minerals present in groundwater solutions showed that the all tested groundwater samples are supersaturated with respect to calcite, aragonite, dolomite, sedirite, rhodochrosite, kaolinite and quartz. This means that these minerals are going to precipitate from groundwater solutions which in turn lead to well intakes encrustation.

Advanced well design criteria should be taken into consideration, chemical analysis of water samples with depths should be carry out to determine good water quality zone. The equilibrium between groundwater composition and well intakes (screens and gravel pack) should be at saturated state to prevent corrosion - encrustation processes and to increase well service life .

1.Introduction

Menufiya Governorate occupies the southern part of the Nile Delta. Quaternary groundwater aquifer is one of the main water resources in the study area. It is characterized by high groundwater potentialities and fresh water quality. It is composed mainly of sand and gravels with occasional thin clay intercalations. Its thickness ranges between 240 to 450 m in Menufiya Governorate. Productive wells of drinking water stations (Fig.1) are tapped this aquifer at depths from 50 and 60 m. It is noticed that the hydraulic efficiency and yields of such wells are decreased and others are abandoned, this is due to encrustation of well intakes which in turn is due to poor well design, excessive discharging rates and poor water quality.

Encrustation is any clogging, cementation or stoppage of a well screen and water-bearing formation which is the result of the collection of material in and about the openings of the screen and voids of the water bearing formation. Encrustation may take the form of a hard, brittle, cement-like deposit and under different condition may be soft and pasty like sludge or stiff jelly. The cause of encrustation in the probable order of occurrence is due to precipitation of materials carried to the screen in solution such as carbonates of calcium and magnesium, suspended materials such as clays, silts, iron and manganese.

Barrens and Clarke (1969) study showed that the equilibrium considerations are useful in establishing a reference for the actual properties and probably encrustation effects of naturally occurring groundwater solutions. The detailed physical and chemical calculations are very useful in understanding the nature and for predicting behaviors of such solutions in water wells and other environment. Quantitative approaches for interpreting concentration distribution in groundwater have developed along two different pathways, one can be termed the chemically oriented approaches and the other can be termed the transport oriented approaches. However, the equilibrium model provided a means to estimate the equilibrium distribution of mass in the weak acid system and among complexes and redox couples. The models also determine the saturation indices for various minerals and study more complexes heterogeneous system that equilibria among aqueous, solid and gas phases.The present work will be discusses encrustation processes and their impact on the well yield, the study was based on discussion of well design criteria, relationship between power pump and hydraulic efficiency of the productive wells and saturation states of relevant minerals in groundwater solution and their relation ship with corrosion-encrustation processes of well intakes.

2. Field investigations and well design considerations :

During well construction operations, certain operations and conceptions should be considered indetail. Gravel packing operations, selection of proper well casing and screens materials, screen lengths and well diameter are also of vital concerns to the structural integrity and longevity of the well. In addition, well cementing operations are without question ultimately responsible for short and long term sanitary protection of the well. Field investigation of the most drinking water stations showed that short screen lengths, narrow effective slote openings, calcareous gravel pack materials are the main factors causing well screen encrustation. Detailed description of these parameters will be given herunder.

2.1 Well Screen lengths :

Many types of encrustation may be due to over pumping which in turn is related to short screen lengths and installation of a pump having excessive capacity for the hydraulic efficiency of the completed well. The balance between well screen lengths and required discharging rate was studied by Walker (1967):

$$L=Q/AeVc\ 7.48$$

where L is the screen length, Q required discharging rate, Vc is the critical entrance velocity and Ae is effective openings area.

If the above equation is applied and a pump of capable of producing only the Q computed in this equation, the potential encrustation should be reduced considerably. An inefficient well, Walker stresses, when pumped at an excessive rate may cause encrustation at or near the hole wall screen interface, which in turn cause a significant increase in the pressure drop at the interface. Field investigation of the pulled screens showed short screen lengths ranging between 19 m and 23 m. These lengths are imbalance with the installed pump power which have capacities between 180 and 220 m^3/h. This led to encrustation of well screens in the most of drinking water stations.

2.2 Screen slot size:

For naturally developed wells, well screen slot size openings should be selected from sieve analysis of the samples collected from the water bearing formation. For a homogeneous formation that consists of fine uniform sand, the size of the screen opening (slot size) is selected as the size that will pass 50 to 60 percent of the sample (Johnson, 1975). The 60-percent passing value is used where the groundwater is not particularly corrosive. For unhomogenous formation and encrusting water, a large slot size that corresponds to a 70- percent passing value is used. Field investigation of the pulled screens showed that the screens are of silky slotted which have very narrow slot openings (less than 0.12mm). The use of this type during well construction operations consider the main cause of well yield decreasing and well abandonment.

2.3. Gravel and filter packs:

The surrounding zone of the well screen is made more permeable by removing and replacing the formation material with an artificially graded gravels. Gravel pack is intended to increase the specific capacity of the well, to prevent migration of formation material into the well, to aid in the construction of the well and to minimize the rate of encrustation by using a larger screen slot opening, where the formation is relatively thin but very permeable and the chemical characteristics of the groundwater suggests a potential for significant encrustation. To select proper graded gravel pack, sieve analysis curves of the water bearing formation and gravel pack should be constructed, the mean grain size of the formation material 50% and that of the gravel are estimated from_grain size curves, the gravel pack ratio (GPR), is also calculated by applying the following equation:

$$GPR=50\% \text{ gravel pack}/50\% \text{ formation}$$

when the gravel pack ratio is from four to five, wells generally have a high efficiency, wells having ratio of seven to ten were considerably less efficient. When ratio are above ten, the wells produced considerable amount of sand and a well with a ratio of twenty produced excessive sand and is considered a complete failure.

Gravel pack materials should be consisting of siliceous rather than calcareous particles. The maximum limit for calcareous materials (including gypsum and anhydrite) is 5 percent. The gravel needs to be clean and have well-rounded grains that are smooth and uniform. In practice a minimum thickness of 5 to 8 cm (2 to 3 inch) is needed to ensure an envelope of gravel around the well screens. In most conditions, the upper limit of gravel pack thickness needs to be about 20 cm (8 inch). Field investigation showed that the above mentioned conceptions are not taken into consideration during gravel packing operation, where gravel pack ratio (GRP) is not applied, this led to migration of fine materials (silt and fine sand) to the well. Moreover it was found that the gravel materials have high percent of calcareous material (gypsum and anhydrite), this percent ranges between 15 and will desolve 25 % of the total volume of gravel materials. These materials precipitate in and about well screens and gravel packs leading to well intakes encrustation.

3. Water-quality considerations:

Groundwater quality can affect to a great extension on the well yield and well service life. Langelier (1936) stated that high pH -value greater than7.5, carbonate hardness more than 300 ppm, dissolved iron more than 1 ppm, dissolved manganese more than 0.5 ppm and dissolved inorganic carbon less than 50 ppm increase potential encrustation in groundwater solutions. The results of the chemical analyses of the collected groundwater samples (Table.1) showed that the yielded ground water is hard, where it has PH -values between 7.6 and 8.1 with exception to two samples which have PH values between 7.4 and 7.3, carbonate hardness ranges from 222 to 368 ppm, dissolved iron from 1.6 to 0.36 ppm, dissolved manganese from 1.2 to 0.61 ppm, silica from 17 from 11 ppm and inorganic carbon from 32 and 51 ppm According to the above mentioned concentrations the water yielded by wells has tendency to precipitate its material in and around well intakes which led to well intakes encrustation.

4. Saturation states considerations :

The saturation states of the groundwater solution affect to a great extent on the well pipes and well intakes. If the groundwater is subsaturated, it has tendency to dissolve material and corrosion processes is expected. If the groundwater is supersaturated, it has tendency to precipitate its material in and around well intakes and encrustation process is expected. The calculations of ion activities and staturation states are very tedious and time- consuming Fortunately hydrochemical models are available which perform such calculations quickly, even on small computers. One of such models will be used herunder.

4.1. Hydrochemical model:

The hydrochemical model named WATEQ (Truesdell and Jones, 1973) which is now available in many versions. A Pascal version 2 of WATEQ named WATEQP which is designed for use Pcs was applied in the present work. For high concentration of dissolved ions, the model PHQITZ (Plumer et al, 1988) uses Pitzer equations can also be useful. WATEQP calculates the equilibrium distribution of species in an aqueous solution and the state of saturation for relevant minerals. The model consists of three files internally documented named WATEQP.ELE., WATEQP.SPE and WATEQp.Min which contain respectively elements, species and mineral thermodynamics data.

4.1.1. Model calculations:

The model calculates the following parameters:

i- Chemical concentrations of ions

The model calculates chemical concentrations of ions in mol/l, meq/l and mg/l

ii-Total inorganic carbon (TIC):

The model calculates total inorganic carbon/ Alkalinity from measured pH or calculates pH from CO2/HCO3/TIC/Alkalinity combinations.

iii-Chemical activity of ions (I):

The model calculates chemical activity of ions from molal concentration of ion (m_i) and activity coefficient (Y).

$$(i)= Y_i.m_i$$

where (i) is the activity of ion (diemensionless), m_i is the chemical concentration of ion (mol/Kg H_2O) and Y_i is the activity coefficient (dimensionless). Activity coefficient is calculated by using the electrostatical Debije-Huckel theory (Lewis and Randall,1961). In this theory, first the ionic strength (I) which describes the number of electrical charges that present in solution is defined by the following equation:

$$I = 1/2 \Sigma m_i. z_i^2$$

where m_i=mol/l and z_i is the charge of ions .

With respect to Activity coefficient, different equations have been proposed to derive activity coefficients (Y_i) from the ionic strength of solution (Stumm and Morgan,1981). One of the most generally applicable relations is the Davis equation (1987) which is valid to I=0.5:

$$\text{Log } Y_i = - Az_i^2 \left([\sqrt{I}/\{1+\sqrt{I}\}] - 0.3I \right)$$

where A is a temperature dependent coefficient (derived from standard tables), z_i is the charge of ions and I is the ionic strength which is derived from the previous equation.

iv- Saturation indices of minerals:

After the calculation of activities of ions in solution, the state of saturation of groundwater samples for any mineral can be obtained. One approach is to compare the solubility product (K) with the analogue product of activities derived from groundwater analyses. The latter is often termed the ion activity product (IAP). Saturation conditions are expressed as the ratio between IAP and K for example as the saturation state: Thus for=1 there is equilibrium, >1 supersaturation and < 1 subsaturation. For larger deviation from equilibrium, a logarithmic scale can be useful like saturation index (SI):

$$SI = \text{Log } [Kiap/Ks]$$

For SI=0 there is equilibrium between the mineral and the solution, SI < 0 reflects subsaturation which indicates dissolution of mineral in solution (corrosion process) and SI >0 reflect supersaturation which indicates precipitation of mineral from solution (encrustation process).

4.1.2. Model output :

The output file contains first the analyzed concentrations in mol/L, meq/L and mg/L, then follows a block with calculated activities, logarithm of activity and activity coefficients for the element and complexes. A block of text follows with saturation indices for relevant minerals. (SI) = Log.IAP/L.KT= log IAP-log K is also included. The output for sample No.1 (Pemam station) is shown in Table(2). The negative sign of the SI means that the solution is subsaturation and dissolution process is expected, the positive sign means that the solution is supersaturation and precipitation process is expected.

5. Discussion of the model results:

Chemical activities of simple ions and complexes, saturation states of the relevant minerals (SI) and geochemical processes are calculated and presented in Tables 2 and 3.Detailled discussion of these items will be given herunder:

5.1 Chemical activities of ions

Among all the cations, Sodium ion is more active followed by calcium and magnesium (Table.2), this indicates that these cations have priority to react with other ions in solution forming dissolving salts. Among the anions the bicarbonates ion is more active and followed by chloride, sulphate is less active, this indicates that the bicarbonate has high tendency to react with other ions forming dissolving salts with appreciable amounts. This is clear from the results of chemical complexes formed in groundwater solutions, where there are several species of bicarbonates represented by H_2CO_3, $CaCO_3$,$Ca(HCO_3)_2$, $MgCO_3$, $Mg(HCO_3)_2$, $NaHCO_3$, Na_2CO_3 $MnOH_3$, Mn CO_3, Fe CO_3.

5.2 Saturation states of relevant minerals:

The tested groundwater samples contain different mineral assemblages (Table.3). Detailed discussion of the saturation states of such minerals will be given herunder:

5.2.1. Carbon dioxide pressure (P-CO_2):

Carbon dioxide plays an important role in dissolution and precipitation processes of carbonate minerals especially calcite. The presence of carbon dioxide with appreciable quantities in groundwater solution leads to dissolution of calcite and the lack of carbon dioxide leads to precipitation of calcite from solution. The tested groundwater samples are subsaturated with respect to carbon dioxide, where it shows negative saturation indices (Table.3). This mean that the initial carbon dioxide is totally consumed through dissolution of carbonate minerals and not replenished by other sources.

5.2.2. Carbonate minerals:

The carbonate minerals present in the studied groundwater samples include calcite, aragonite, dolomite, sedirite and rhodochrosite (Table.3). The tested groundwater samples are supersaturated with respect to these minerals, where they have positive saturation indices (Table.3).This means that these minerals are going to precipitate from groundwater solution and lead to encrustation of well screens and gravel packs.

5.2.3. Silica:

Silica presents in studied groundwater samples appears in the form of quartz, chalcedony and sepiolite (Table.3). The tested groundwater samples are supersaturated with respect to quartz, where it shows positive saturation indices (Table.3) and they are nearly at saturated state with respect to chalcedony where it shows saturation indices between -0.07 and -0.2. This means that quartz is going to precipitate from groundwater solution and leads to encrustation of well intakes. With respect to sepiolite, the yielded groundwater is subsaturated which means dissolution of sepiolite in groundwater solution.

5.2.4. Clay minerals:

Clay minerals present in the studied groundwater samples appear in the form of kaolinite (Table.3). The tested groundwater samples are supersaturated with respect to kaolinite, where it shows positive saturation indices (Table.3), this means that the kaolinite is going to precipitate from solution and leads to encrustation of gravel packs and wells screens.

5.2.5. Sulphate minerals :

Sulphate minerals present in the studied groundwater samples appear in the form Gypsum. The tested groundwater samples are supersaturated with respect to gypsum , where it shows negative saturation indices (Table.3). This means that gypsum is going to dissolve in groundwater solution.

Recommendations:

1- Careful treatment of the encrusted well screens should be performed, three possible approaches for accomplishing well treatment are (1) pull the encrusted screens, treat them to remove the encrusting materials and resets, (2) pull and replace with new screens that are characterized by suitable screen lengths and large slot openings size (Bride slotted screens). (3) treat the screens and water bearing formation with inhibited acid or other solutions without pulling the screens . Agents such as sulfamic acid, hydrochloric acid, high concentration of chlorine gas and hydroxyacetic acid are in common use. The second solution (2) is the suitable one of the present case study.

2- Advanced well design criteria should be applied for the new wells which include graded siliceous gravel packs material, large slot openings and sufficient screen lengths.

3- Detailed chemical analysis of groundwater with depth should be carry out during well construction to determine good groundwater quality zone (soft water) which increase well service life.

4-Periodical field investigations of water stations should be carry out to predict any decrease in the well yield.

5- Periodical chemical analyses of the yielded groundwater should be carry out to predict any change in the chemical concentrations of different elements with time.

References

Barrens, I.and Clarke,F.E., 1969: Chemical properties of groundwater and their corrosion and encrustation effects on wells. U.S Geol. Surv. Prof. Paper 498-D, 58 pp. 47

Davis, J. A., Fuller,C.C. and Cook, A.D. 1987: A model for trace metal sorption processes at the calcite surface : Adsorption of Cd and subsequent soled solution formation. Geochim. Cosmochim. Acta 51, pp. 1477-1490.

Lewis,G. N and Radall, M, 1961: Thermodynamics.2nd ed..McGraw-Hill, New York , 723 pp.

Johnson Division, UOP. Inc., 1975: Groundwater and wells. St. Paul, Minn., 440 PP

Longelier, W.F.,1936: The analytical control of anti-corrosion water treatment. Jour. Of the Am. Water works Assoc., 28, PP 1500-1521

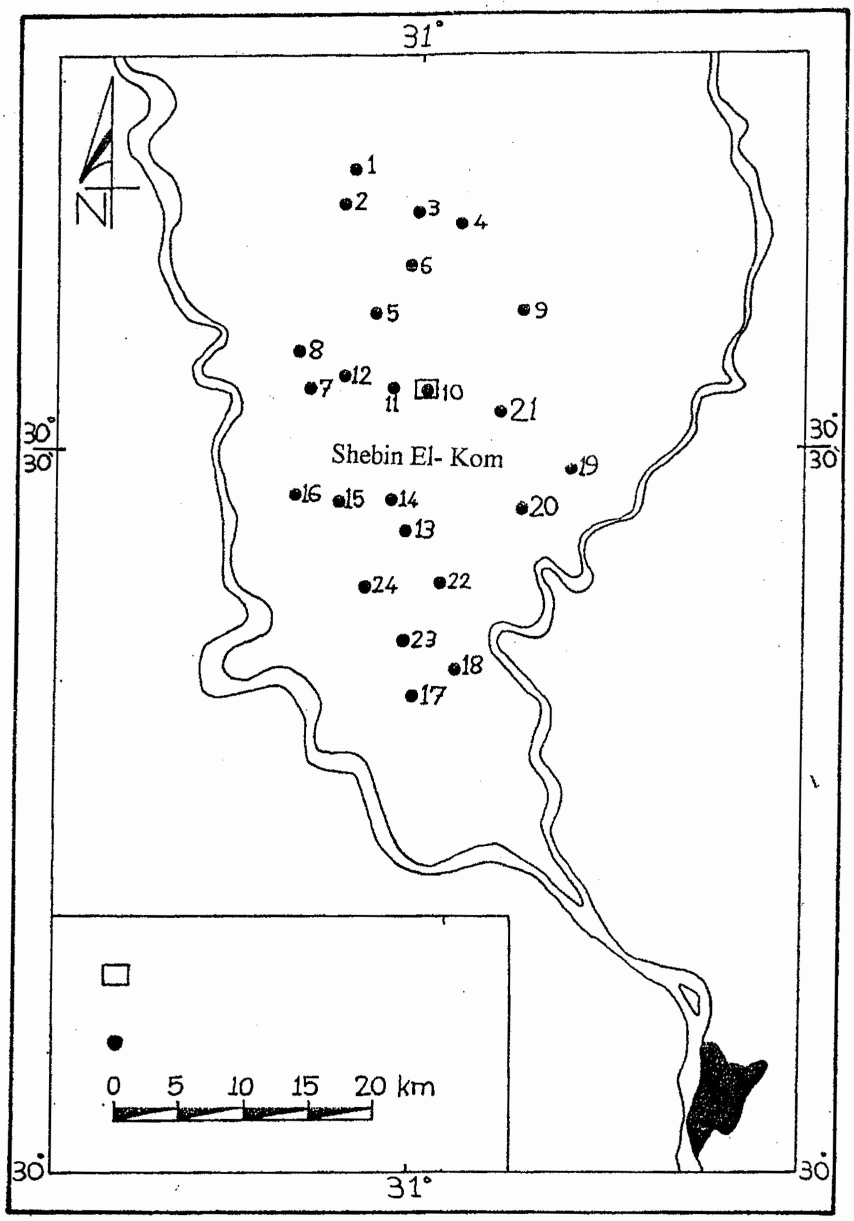
Plummer, L.N. parhurst,D. L, Fleming, G.W and Dunkle,S.A., 1988 : A computer program incorporating pitzers equations for calculation of geochemical reactions in brines. U.S. Geol. Surv. water Resour. Inv.Rep. pp. 88-4153.

Stumm,W and Morgan, J.J., 1981: Aquatic Chemistry. 2nd Ed Wiley & Sons, New York, 780 pp.

Trundle, ASH. and Jones, B.F., 1973: Water a computer program for calculating chemical equilibrium of natural waters.US Geol. Sure., National Technical Information Service, PB220-464,73 pp.

Ryzner, J. W., 1944: A new index for determining the amount of calcium carbonate scale formed by water . Jour. of Am. Water works Assoc., 36, PP 472-486.

Walker, W. H., 1967: When not to acidize, Groundwater, Vol.5, No.2 April, pp36-40.



(Fig.1) Location map of the tested drinking water stations

Table (1): Shows results of chemical analyses of the collected groundwater samples

Station	Depth	pH	E.C	TDS	Ca	Mg	TH	TIC	Fe	Mn	SIO2
pemam--1	57	8.1	1145	709.9	63	36	304.7	34	o.9	0.6	13.6
Tala-2	73	7.8	1119	693	56	31	268.8	42	.36	0.99	15
Zinnara-3	68	7.6	896	555.5	54	34	273.7	37	0.65	0.8	11
Ganzorr-4	57	7.7	1045	647.9	62	37	306.4	46.1	1.2	0.65	14.78
Batanon-5	63	7.6	1108	686.9	64	41	327.8	47	0.67	0.76	14.6
Samaleg-6	54	7.8	1214	752.6	64	39	319.6	32	0.7	1..2	16
shohadaa-7	62	8.1	1200	744	62.2	42	328.1	35	1.2	1.01	14
Shemiats8	62	7.8	965	598.3	48	32	260.8	41	0.8	0.71	16
Berket -9	61	7.3	876	543.1	44	29	228.7	37	0.76	0.67	17
Shebin-10	64	7.8	765	474.3	43	28	222.4	42	0.67	0.87	13
Tukh-11	57	7.6	1107	686.3	65.2	41	355.5	38	1.03	0.67	14
Sarmos-12	62	8.1	1121	695	63.3	45	368	43	0.92	0.54	13
Shanshor-13	57	7.9	879	544.8	54.2	33.41	293.5	38	1.06	0.89	16
Telwana-14	55	8.2	1119	693	61	34	300	43	0.89	0.67	13.8
Ramlet-15	61	8.1	1268	786	75	43	362	51	1.6	0.74	14.8
Abu Raqb-16	57	8.1	1123	696	63	44	334	46	1.4	-.78	15.6
Sentrece-17	67	7.8	789	489	56	36	286.9	43	0.76	0.61	14
Sobk-18	58	8.1	1103	683	57	41	309	43	1.05	0.87	13
Taha-19	57	7.8	781	484	45	36	258	51	0. 78	0.68	12
Um Khenan-20	61	8.1	1112	675	62	36	304	48	1.1	0.65	16

Table.(2) : Shows the model output of sample No.1 (Pemam station)

```
pEMAM
Temp.= 23.4    pH =  8.100   Alkalinity used for C-species

Conc. in  mmol/l     meq/l      mg/l

Na+         3.306     3.306     76.000
K+          0.307     0.307     12.000
Mg++        1.481     2.963     36.000
Ca++        1.572     3.144     63.000
NH4+        0.002     0.002      0.030
Cl-         3.047     3.047    108.000
HCO3-       4.948     4.948    301.927
SO4--       0.437     0.874     42.000
NO3-        0.003     0.003      0.200
Fe++        0.016     0.032      0.900
Al          0.013     0.038      0.340
SiO2        0.226     0.000     13.600

TIC         5.241               62.945
Alk                   5.261    321.000

Sum +ion =   9.36   Sum -ion =  -8.81  Electrical balance=  3.0%

  Element  Activity  Log Act.  Act.coef Element  Activity  Log Act.  Act.coef

  Na+      2.94E-03   -2.531     0.893  K+       2.74E-04   -3.563     0.893
  Mg++     8.76E-04   -3.058     0.637  Ca++     9.15E-04   -3.039     0.637
  NH4+     1.40E-06   -5.853     0.893  Cl-      2.72E-03   -2.565     0.893
  HCO3-    4.42E-03   -2.355     0.893  SO4--    2.27E-04   -3.645     0.637
  NO3-     2.88E-06   -5.540     0.893  Fe++     9.77E-06   -5.010     0.637
  Al       6.05E-15  -14.218     0.362  SiO2     2.24E-04   -3.651     1.003


  CO3--    2.52E-05   -4.599     0.637  H2CO3    8.07E-05   -4.093     1.003
  NH3      9.08E-08   -7.042     1.003  CaOH+    2.53E-08   -7.596     0.893
  CaCO3    3.74E-05   -4.427     1.003  CaHCO    5.02E-05   -4.300     0.893
  CaSO4    4.17E-05   -4.380     1.003  MgOH+    1.55E-07   -6.809     0.893
  MgCO3    2.06E-05   -4.686     1.003  MgHCO    4.50E-05   -4.347     0.893
  MgSO4    3.49E-05   -4.458     1.003  NaCO3    1.27E-06   -5.898     0.893
  NaHCO    7.31E-06   -5.136     1.003  NaSO4    3.46E-06   -5.460     0.893
  KSO4-    4.27E-07   -6.369     0.893  FeOH+    3.45E-07   -6.462     0.893
  FeOH2    3.21E-10   -9.493     1.003  FeOH3    1.48E-12  -11.830     0.893
  FeSO4    3.82E-07   -6.417     1.003  AlOH+    6.99E-12  -11.155     0.637
  AlOH2    7.62E-09   -8.118     0.893  AlCH3    1.21E-06   -5.918     1.003
  AlOH4    1.02E-05   -4.993     0.893  AlSO4    1.41E-15  -14.851     0.893
  AlSO4    2.52E-17  -16.598     0.893  H3SiO    3.03E-06   -5.518     0.893
  NH4SO    4.01E-09   -8.397     0.893  HSO4-    1.66E-10   -9.779     0.893
  H2SiO    6.35E-10   -9.197     0.637  OH       1.12E-06   -5.951     0.893

-----------------------------------------------------------------------------

Printout of SI also in Spreadsheet file C:\WATEQP\WATEQP\PEMAM-1

 Mineral     Log IAP  Log KT  L.IAP/KT Mineral     Log IAP  Log KT  L.IAP/KT

  Calcite       2.71    1.87      0.83 Dolomite       5.39    3.70      1.69
  Siderite      0.74   -0.18      0.92 Gypsum        -6.68   -4.60     -2.08
  Chalcedony   -3.65   -3.54     -0.11 Quartz        -3.65   -4.03      0.38
  Gibbsite     10.08    8.86      1.22 Kaolinite     12.86    9.23      3.63
  Sepiolite    15.33   16.03     -0.69 P-CO2        -10.45   -7.81     -2.65
  Aragonite     2.71    2.02      0.69
-----------------------------------------------------------------------------
```

Table(3): Shows the results of saturation states of relevant minerals and geochemical processes of groundwater samples;

Stations localities	Calcite		Aragonite		Dolomite		Gypsum		Gibbsite		Sedirite		Rhodochr-osite		Kaolinite		Quartz		Chalcedony		Sepiolite		P-Co2	
	SI	Process	SI	Process	SI	Process	SI	Process	SI	Process	SI	Process	SI	Process	SI	Process	SI	Process	SI	Process	SI	Proc-ess	SI	Proc-ess
Pemam-1	0.83	PPt	0.69	PPt	1.69	PPt	-2.08	Diss	1.22	PPt	0.92	PPt	0.68	PPt	3.63	PPt	0.38	PPt	-.11	Diss	-.69	Diss	-2.6	Diss
Tala-2	0.47	PPt	0.33	PPt	0.96	PPt	-2.1	Diss	1.8	PPt	0.24	PPt	0.52	PPt	4.87	PPt	0.43	PPt	-0.06	Diss	-1.8	Diss	-2.3	Diss
Zinnara-3	0.21	PPt	0.06	PPt	0.48	PPt	-2.15	Diss	2.19	PPt	0.22	PPt	0.18	PPt	5.39	PPt	0.29	PPt	-0.2	Diss	-2.9	Diss	-2.2	Diss
Ganzor-4	0.37	PPt	0.22	PPt	0.78	PPt	-2.12	Diss	1.97	PPt	0.59	PPt	0.19	PPt	5.21	PPt	0.42	PPt	-0.07	Diss	-2.1	Diss	-2.3	Diss
Batanon-5	0.29	PPt	0.14	PPt	0.65	PPt	-2.1	Diss	1.94	PPt	0.25	PPt	0.16	PPt	5.13	PPt	0.42	PPt	-0.07	Diss	-2.4	Diss	-2.2	Diss
Samaleq-6	0.55	PPt	0.14	PPt	1.16	PPt	-2.08	Diss	1.7	PPt	0.52	PPt	0.62	PPt	4.73	PPt	0.45	PPt	-0.04	Diss	-1.6	Diss	-2.3	Diss
Shodaa-7	0.86	PPt	0.71	PPt	1.82	PPt	-2.11	Diss	1.44	PPt	0.9	PPt	0.87	PPt	4.08	PPt	0.39	PPt	-0.1	Diss	-0.5	Diss	-2.6	Diss
Shemiata-8	0.40	PPt	0.25	PPt	0.89	PPt	-2.22	Diss	1.59	PPt	0.56	PPt	0.37	PPt	4.5	PPt	0.45	PPt	-0.04	Diss	-1.7	Diss	-2.3	Diss
Berket-9	0.28	PPt	0.13	PPt	0.64	PPt	-2.25	Diss	1.59	PPt	0.4	PPt	0.39	PPt	4.33	PPt	0.36	PPt	-0.13	Diss	-2.1	Diss	-2.4	Diss
Shebin-10	0.52	PPt	0.12	PPt	0/61	PPt	-2.67	Diss	1.03	PPt	0.87	PPt	0.61	PPt	3.43	PPt	0.41	PPt	-0.06	Diss	-1.7	Diss	-2.3	Diss
Tukh-11	0.34	PPt	0.19	PPt	0.76	PPt	-2.16	Diss	1.61	PPt	0.49	PPt	0.17	PPt	4.44	PPt	0.4	PPt	-0.09	Diss	-2.5	Diss	-2.1	Diss
Sarsamos-12	0.83	PPt	0.68	PPt	1.78	PPt	-2.16	Diss	1.2	PPt	0.92	PPt	0.56	PPt	3.55	PPt	0.36	PPt	-0.13	Diss	-0.5	Diss	-2.6	Diss
Shanshor-13	0.55	PPt	0.4	PPt	1.15	PPt	-2.18	Diss	1.38	PPt	0.77	PPt	0.56	PPt	4.09	PPt	0.45	PPt	-0.04	Diss	-1.3	Diss	-2.5	Diss
Telwana-14	0.99	PPt	0.76	PPt	1.82	PPt	-2.15	Diss	1.11	PPt	1	PPt	0.75	PPt	3.55	PPt	0.45	PPt	-0.04	Diss	-0.1	Diss	-2.8	Diss
Ramlet-15	0.93	PPt	0.79	PPt	1.9	PPt	-2.03	Diss	1.2	PPt	1.2	PPt	0.73	PPt	3.66	PPt	0.42	PPt	-0.07	Diss	-0.5	Diss	-2.6	Diss
Abu Rakaba-16	0.82	PPt	0.67	PPt	1.75	PPt	-2.09	Diss	1.12	PPt	1.1	PPt	0.71	PPt	3.55	PPt	0.44	PPt	-0.05	Diss	-0.4	Diss	-2.7	Diss
Senres-17	0.41	PPt	0.27	PPt	0.9	PPt	-2.22	Diss	1.38	PPt	0.48	PPt	0.25	PPt	3.98	PPt	0.4	PPt	-0.09	Diss	-1.8	Diss	-2.4	Diss
Sobk-18	0.78	PPt	0.64	PPt	1.69	PPt	-2.12	Diss	1.12	PPt	0.98	PPt	0.77	PPt	3.39	PPt	0.36	PPt	-0.13	Diss	-0.6	Diss	-2.7	Diss
Tah-19	0.34	PPt	0.19	PPt	0.85	PPt	-2.28	Diss	1.38	PPt	0.51	PPt	0.32	PPt	3.92	PPt	0.31	PPt	-0.12	Diss	-1.9	Diss	-2.4	Diss
Um Khenan-20	0.67	PPt	0.21	PPt	0.85	PPt	-2.11	Diss	1.43	PPt	0.65	PPt	0.42	PPt	3.56	PPt	0.36	PPt	-0.13	Diss	-1.6	Diss	-2.5	Diss

SI> 0 (Supersaturation) SI< 0 (Subsaturation) SI=0 (Satauration) Diss= Dissolution process Ppt= Precipitation process

مواصفات تصميم الأبار ومعدل الكلسنة للمياه الجوفية وتأثيرهما على كفاءة البئر (حالة دراسية محافظة المنوفية - مصر)

كمال دهب

قسم الجيولوجيا - كلية العلوم - جامعة المنوفية

يناقش البحث الحالى أسباب انخفاض كفاءة الآبار الإنتاجية وإغلاق معظمها بعد فترة قصيرة من إنشائها للمحطات مياه الشرب بمحافظة المنوفية.

قد اعتمدت الدراسة على المسح الحقلى لمحطات مياه الشرب وكذلك تجميع وتحليل عينات المياه منها كما تم استخدام أحد النماذج الهيدروكيميائية لتحديد التركيب الكيميائى للمياه وكذلك تحديد الإتزان المعدنى وحالات التشبع للمعادن المختلفة الموجودة فى المياه الجوفية والتى تسبب كلسنة الغلاف الزلطى والمصافى للأبار.

وقد تبين أن قصر طول المصافى وكذلك استخدام مصافى من نوع ذات فتحات -ضيقة جدا وغلاف زلطى يحتوى على نسبة كبيرة من المواد الكلسية يعتبر من العوامل الأساسية فى خفض كفاءة الآبار نتيجة لكلسنة الغلاف الزلطى والمصافى للأبار.

كما بينت نتائج التحاليل الكيميائية للعينات المجمعة أن المياه المنتجة من النوع العسر (ماء كلسي) كما تبين أن معظم العينات عالية التشبع بمعادن الكاسيت والأراجونيت والدولوميت والسيدريت والكوارتز والروهوكورزيت وهذا يعنى أن هذه المعادن تترسب فى فتحات المصافى وفىالفرغات الموجودة فى الغلاف الزلطى مما يؤدى إلى كلسنة تلك المناطق.

لهذا يلزم تطبيق المواصفات العلمية أثناء تصميم الآبار لمحطات مياه الشرب بالمحافظة وتحليل المياه مع الأعماق لتحديد نطاق المياه الجيدة كما يلزم تحديد الإتزان المعدنى للمعادن الموجودة بالمياه حفاظا على سلامة الآبار وزيادة عمر البئر.