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Hydrological analysis of the discharge Alsharhani basin and his secondary basin by using the SCS-CN equation

By

Fatma Ali A Kazem
Department of Geography and Geographical Information Systems/ College of Arts - University of Baghdad – Iraq
Email: Fatma.Ali1207a@coart.uobaghdad.edu.iq

Abdullah Sabbar Abood
Department of Geography and Geographical Information Systems/ College of Arts - University of Baghdad - Iraq
Email: Abdallahsabbar@coart.uobaghdad.edu.iq

Abstract

Hydrological studies are an important step to complete knowledge of river basins, as well as their association with the areas of water resource development and agricultural development projects in the studied basins. These basins lack the stations to measure runoff, so that they depend on the application of mathematical equations calculating precipitation amounts and characteristics of runoff to determine hydrological budget. In addition, one of the most important and common used ways to estimate runoff (SCS-CN) is beveloped by the U.S. Soil Conservation Authority. It is a method that estimates the volume of direct runoff from the rainstorm.

Keywords: water basins, CN equations, runoff, soil permeability

Research problem

What are the hydrological forms of Al-Sharhani basin according to the (CN) equation?

Research hypothesis

There are many hydrological forms of Al-Sharhani basin through the use of the (CN) equation.

Limits of the study

The study area is located astronomically between latitudes 20° 32°-27° 32° north, and longitudes 20° 47°-10° 47° east. Al-Tayyib from the north, Doerij River from the south, and from the east, it is bordered by the Islamic Republic of Iran, and from the west by the Tigris River.

Equations for extracting the values of (CN) surface runoff according to the (SCS-CN) method:

The US Soil Conservation Service (SCS-CN) was relied on to calculate the volume of surface runoff, which is a series of mathematical equations, which depend in its inputs on the type of soil, land uses, type of land cover the amount of rain and soil moisture, using a computer program (Watershed Management System 10.1). Its outputs are determined by the digital curve and the amount of water reaching the valleys estuaries. The following are the most important mathematical equations and stages in calculating the volume of surface runoff (USDA-TR55,1986,1):

First equation

$$Q = (P - Ia)^2 \div (P - Ia + s)$$

Here,

Q is depth of runoff mm P refers amount of rain mm Ia stands for the losses before the start of runoff

Surface (evaporation, seepage, vegetation) S is surface assembly after the onset of runoff

Since the value of Ia is equivalent to one-fifth of the value of S, the value of Ia is calculated according to the second equation.

Second equation

$$Ia = 0.2 \times S$$

According to the second equation, the equation will be as proven in the third equation.

Third equation

$$Q = (P - 0.2 \times S)^2 \div (P + 0.8 \times s)$$

The calculation of the value of S is done through the following formula, which is proven in the

Fourth equation

$$S = [(1000) \div (CN)] - 10$$

To convert the units of the fourth equation to (mm) to correspond to the metric measures, the following formula installed in the fifth equation is used:

Fifth equation

$$S = (25400 \div CN) - 245$$

To calculate the surface runoff, it is necessary to determine the values of the digital curve (CN), and it depends on three elements in extracting the values of the digital curve, which are called (the hydrological group of the soil). They are the land cover, land uses and soil moisture. The values of the (CN) range between (0 - 100). They represent the highest and lowest surface runoff, and low values indicate the high permeability of surfaces and the leakage of water through them into the soil, which leads to a decrease in its ability to generate surface runoff, while high values represent the exact opposite, meaning that the surfaces are less permeable and their ability to generate runoff is high. The average values (50) mean that the surfaces are of medium permeability(Nachiappan, 1998).

The Weighted Curve Number (CNw) is calculated by using each value in CN in the proportion it represents from the area of the basin, then summing it and dividing it by the total area of the basin, which is extracted from the sixth equation and appendix (1) using the (WMS v10) program. 1) To know the level of permeability for each basin and the ability of the basins to generate runoff(Al-Ghurabi, 2021).

Sixth equation

$$CN\ composite = [(A_1 \times CN_1) + (A_2 \times CN_2) + (A_3 \times CN_3) + (A_4 \times CN_4) + (A_5 \times CN_5)] \div A_1 + A_2 + A_3 + A_4 + A_5$$

In the above euqtaion, CN1 CN5 are value of each type of soil cover.
A1.A5 arethe area of each type of soil cover.

On applying the above equations and through Table (1) and Appendix (1) and maps (1-4) that show the values of (CN) and the water response of the components of the land cover in the studied drainage basins, and express the amount of permeability of the surfaces

Table (1) *values of (CN) within the different states and permeability ratios in the Al-Sharhani basin and its secondary basins*

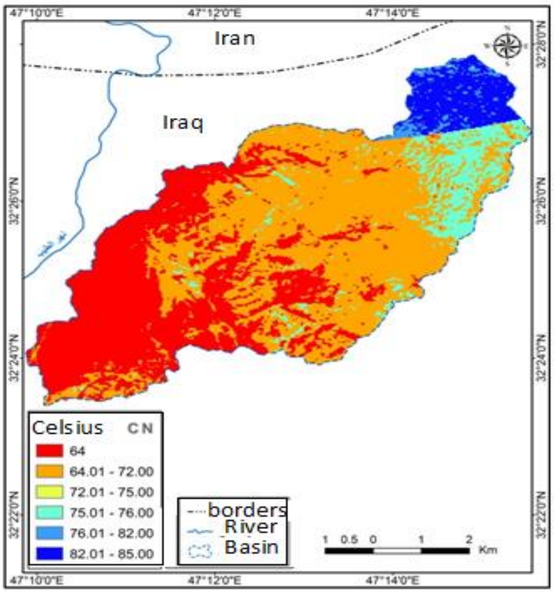
No	**CN values in normal condition**	**CN values in the wet state**	**CN values in the dry state**	**Total**		**B1**		**B2**		**B3**	
				area	**rate**	**area**	**rate**	**area**	**rate**	**area**	**rate**
1	44	69.25	35.14	2.15	1.58	1.05	2.92	2.23	2.31	0.09	2.50
2	65	72.14	46.75	8.91	6.54	1.91	5.31	6.25	6.46	0.07	1.94
3	72	75.25	59.35	10.36	7.6	1.46	4.06	8.25	8.53	0.14	3.89
4	74	78.33	61.02	1.25	0.92	2.25	6.25	1.19	1.23	0.12	3.33
5	79	80.64	64.26	1.58	1.16	0.43	1.2	1.44	1.49	0.05	1.39
6	80	80.77	68.10	1.32	0.97	2.21	6.14	1.37	1.42	0.13	3.61
7	82	80.79	77.88	65.22	47.86	15.08	41.91	42.09	43.53	1.02	28.33
8	85.14	86.18	78.45	1.27	0.93	1.32	3.67	1.16	1.2	0.16	4.44
9	87.26	88.35	80.24	1.83	1.34	1.11	3.09	1.41	1.46	0.19	5.28
10	88	90.26	84.15	38.38	28.16	5.29	14.7	27.12	28.05	1.01	28.06
11	88.34	92.47	86.64	1.19	0.87	1.35	3.75	1.39	1.44	0.18	5.00
12	89.25	94.35	87.11	1.28	0.94	1.14	3.17	1.32	1.35	0.19	5.28
13	90.27	95.56	88.23	1.54	1.13	1.18	3.28	1.36	1.41	0.14	3.89
14	100	100	100	-	-	0.20	0.56	0.12	0.12	0.11	3.06
-	-	-	-	136.28	100%	35.98	100%	96.70	100%	3.60	100%
CN ratios in the normal case				82.77		81.27		82.72		78.62	
Permeability ratios in the normal case				19.21		18.53		18.49		20.22	
CN ratios in the wet state				91.24		91.59		91.64		89.15	
Permeability ratios in the wet state				10.11		9.28		9.38		11.17	
CN ratios in the dry state				77.47		79.23		79.23		71.49	
Permeability ratios in the dry state				33.15		31.58		31.58		39.35	

This table is prepared based on the equations of (CN) and maps.(4-1)

The basins and their ability to absorb water, that is, they show the ability of the water basin to generate surface runoff, as it turns out that the components of the studied water basins have a direct impact on their hydrology. The high indicators of the dangers of the basins to reach the values of (CN) high ratios contribute to the events of water runoff after rainfall and low Tpercentages of water penetrating into the subsurface layers. Here, the permeability rates were according to the (CN) values for the Al-Dursa Al-Sharani basins (19.21), (18.53) for the (B1) basin, (18.49) for the (B2) basin and (20.22) for the (B3) basin. Expressed in the four study basins, it reached (14) and ranged between (44) for the most permeable and least able areas to generate surface runoff and between (100) for the non-permeable areas and most capable of generating surface runoff, and from a review of Table (1) it appears that the values of CN varies between basins, but it is high. This means that the studied basins have low permeability in some parts, which makes the surfaces tend to produce surface water runoff.

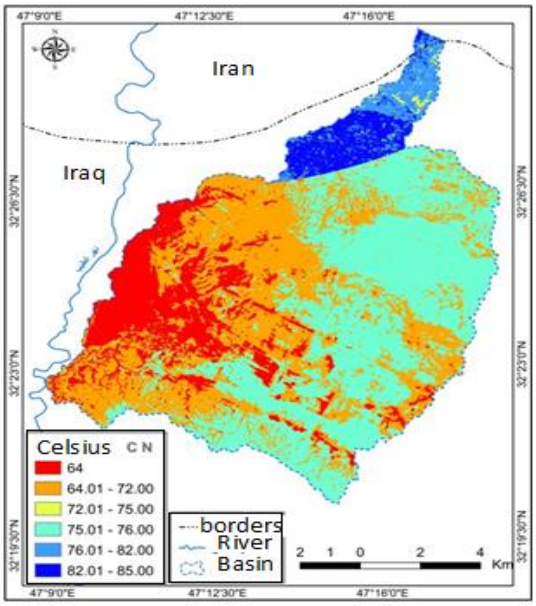
It was also shown from the same table that the most distributed (CN) values are the value (82), which expresses a response of (123.41) km2, which constitutes (45.27%) of the area of the studied basins. Also, the highest values of (CN) were in the Al-Sharhani basin. The chief, when it scored (82.77), came to the basin (B2) in terms of the value of (CN) by (82.72). Then the basin (B1) scored (81.27), and the lowest value was in the basin (B3), which recorded (78.62), and it is noted from these figures (CN) it is high values close to (100), which indicates high surface runoff and low level of permeability with a slight discrepancy between the basin.

Map (1) *Percentages of Runoff (CN)*



Source: *the researcher based on the map (hydrogen classification) and map (land cover classification), using the Arc GIS 10.4.1 program*

Map (2) *Percentages of Runoff (CN) Al-Sharhani basin.*

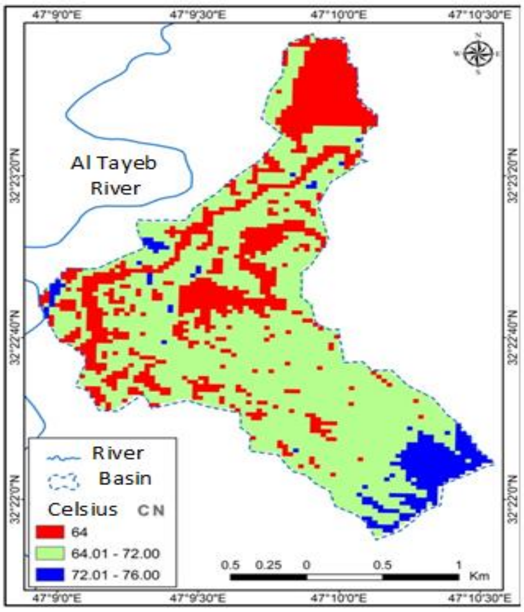


Source: *The researcher based on the map (hydrogen classification) and the map (land cover classification) using the Arc GIS 10.4.1 program*

Raw land cover data analysis (Digital Grant Extraction)

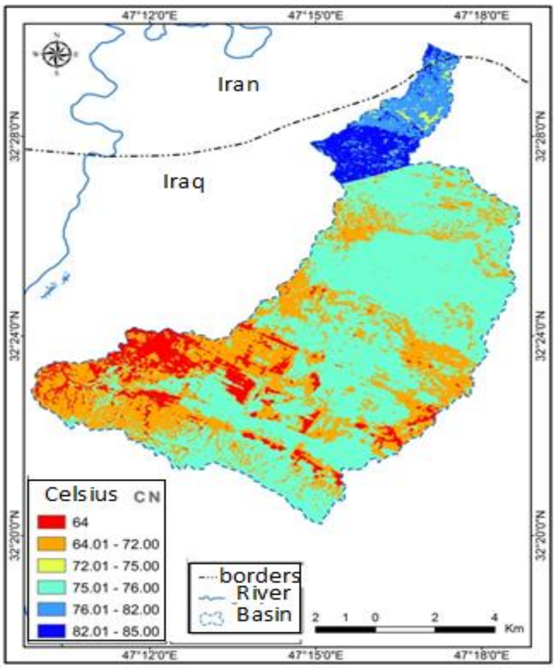
The method of extracting the numerical curve (CN) depends on a group of factors that affect the generation and emergence of runoff, which are the characteristics of soil, land cover and soil moisture (AMC). Accordingly, the relationship between rainfall and runoff is affected by soil characteristics. SCS is a classification (which is considered a ladder of soil types) of hydrological soils that define their types in four types or four classes.

Map (3) *percentages of runoff basin B2 (CN)*



Source: *the researcher based on the map (hydrogen classification) and map (land cover classification), using the Arc GIS 10.4.1 program*

Map(4) *percentages of runoff basin B3 (CN)*



Source: *The researcher based on the map (hydrogen classification) and the map (land cover classification) using the Arc GIS 10.4.1 program.*

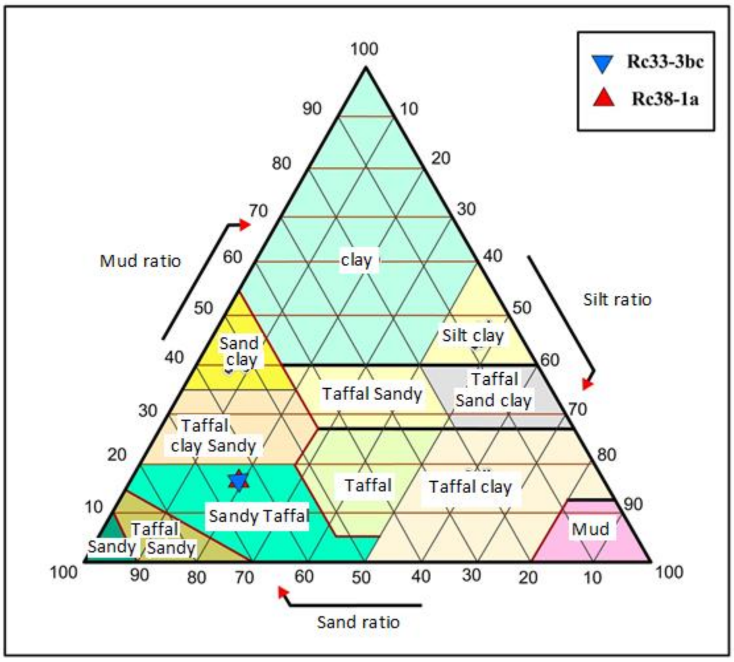
Sand, clay and green (USDA,2009,2-3), and the land cover uses were classified in the study area, as the soils of the study area were divided into three hydrological groups of soils and based on the scale of soil classes listed in Table (2). It depends on the texture of the soil figure (1) and maps (5-7). The soils were divided into two groups, namely category (B) and category (C) and table (3), and the following is a presentation of the soil categories in the study area (Al-Sharhani basin and its secondary basins):

Table (2) *Soil types and their textures*

No	Soil texture	Soil type		Soil texture	Soil type
1	Sand	A	7	Sandy Clay Loam	C
2	Loamy Sand	A	8	Clay Loam	D
3	Sand Loamy	A	9	Silty Clay Loam	D
4	Loam	B	10	Sandy Clay	D
5	Silt Loamy	B	11	Silty Clay	D
6	Silt	B	12	Clay	D

(Abraham, Huynh, & Vu, 2019)

Figure (1) *Soil texture triangle in Al-Sharhani basin*



This is made based on the Soil Classification Scale (SCS) and Table (2) and Asling (1983)

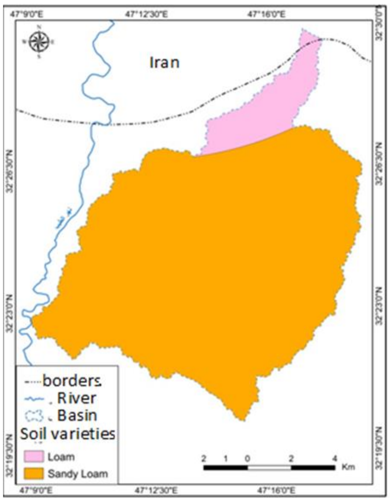
Table (3) *Types of hydrological soils in the study area*

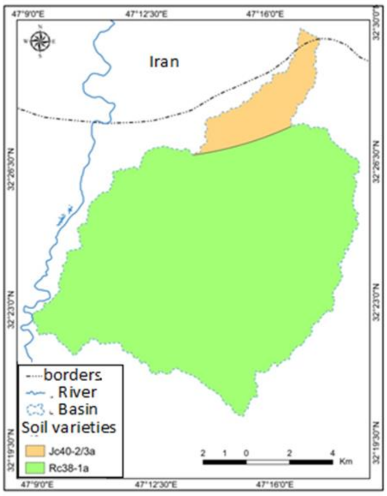
No	Soil type	Area/km2	Percentage %	grit%	Green%	clay%
1	Rc38-1a	124.73	91.52	63.5	19.2	17.3
2	Rc33-3bc	11.55	8.48	63.5	17.3	19.2
Total	-	136.28	100	-	-	-

Source: *the researcher based on Map (6) and using the Arc GIS 10.4.1 program.*

Soil category (B): It is a deep to medium depth soil, its texture is sandy alluvial clay.

Map (5) *Types of soil in the Al-Sharhani basin Map (6) types of tissues (clay and sandy according to the clay CN) in the Al-Sharhani basin*



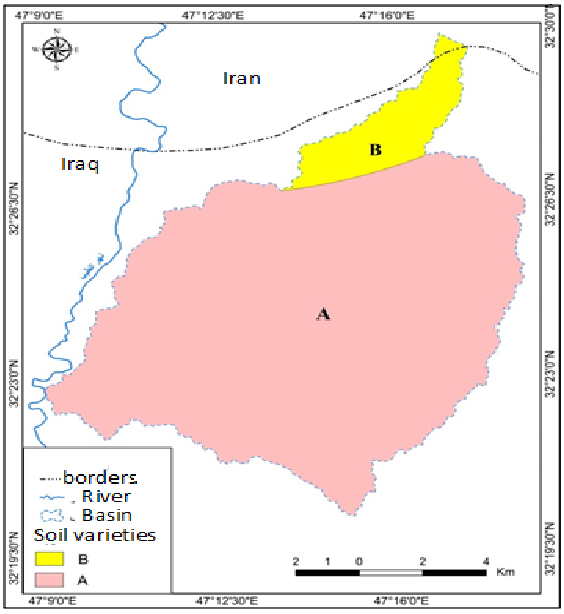


Soil category (B): It is a deep to medium depth soil, its texture is sandy alluvial clay.

The pictures are prepared based on appensxi (1) and mape (1) by using Arc GIS 10.4.1

It is soft to medium rough in this category (in case the soil is wet). Also, the possibility of surface run-off and the rate of infiltration are medium, with an area of (124.73) km2 with a percentage of (91.52%) of the area of the main Al-Sharhani basin. It is the largest area among the soils of the basin, and the level of the permeability in this category is good, as is the spread of this type of soil in most parts of the basin and is concentrated in the upper parts of the basin, as well as the southern and southeastern parts at the mouths of the sewers.

Map (7) *Tissue classes (classes A and B) in the Al-Sharhani basin*



The researcher made this figure according to Appendix (1), Figure (1) and Map (1), using the Arc GIS 10.4.1 program. Soil category (C) is the texture of this soil is sandy-clay and the level of permeability is medium, which leads to the rate of leakage in it It is also medium when the soil is wet to increase the proportion of clay in it than the silt. This soil was formed in the central and southern parts of the basin due to the flooding of surface waterways at the time of rain. Al-Sharhani, the president.

Preconditioning Soil Moisture (AMC):

The valleys in the dry areas lack more studies and research that would enable decision-makers to identify their various aspects and characteristics in preparation for their exploitation and the development of water sources and development projects, in areas where there are no hydrological stations to measure surface runoff. The numbers curve (CN) will be used, which is one of the best and most accurate methods, as it proves the relationship between rain and runoff. The US Soil Conservation Service developed this method in 1954 to measure rainfall, which was taken from special tables. and its secondary basins(Al-Jubouri, 2018), the CN equations were applied, and the types of soils were determined hydrologically. The composition of the flow, and this coefficient is an important variable in determining the values of (CN), and we must mention here that the US General Soil Conservation Service (SCS) has identified three cases of pre-moisture soils It is (III, AMC, AMC-II, AMC-1) and the first case is used for dry areas and the usual case is used for semi-arid areas, while the third case is used in humid, heavy rain areas with low temperatures, and it can be said that each of these cases has values Its own CN, where the pre-condition of soil moisture is determined on the basis of the total rainfall for five consecutive days before calculating the runoff, and the usual case was adopted to determine the values of (CN)(Salih, 2021). The value of CN is adopted based on three elements (hydrological groups of soils, land uses, soil moisture pre-condition). It expresses the water response to the components of land uses between high and low water permeability. The value of the (CN) curve ranges between (0 - 100) and the more values go towards (100). This indicates that the surfaces of the basins are of low permeability, while the direction of the values towards (0) expresses that the permeability is high for the surfaces of the basins. The pre-condition of soil moisture was determined in the normal state (AMC-II), and maps were prepared for the hydrological groups of the soil for each of the drainage basins extracting the numerical value of the flow curve through the process of integrating (Combine) within the geographic information systems (GIS) and then giving each one of them a special code. The result was obtaining seven layers representing the distribution of (CN) values in the basins of the study area as shown in Table (4) , as it turns out that the expressive values reached (6) that ranged between (70) for the areas with the most water permeability and the least ability to generate surface runoff, and between (100) for areas that are not filtered for water. Here, the rate of (CN) in the first, second and third basins reached (94.5), while in the fourth basin it reached (84), and it is also noted from Table (4) that the value of (94) is the most distributed value of (CN) as it constitutes (30.41)% of the basin area. So, the distribution of hydrological soils is predominantly (type C), and this indicates the high values of (CN), which means its ability and ability to create water flow, low permeability, and the ability of Al-Sharhani basin and its secondary basins to convert rain precipitation into surface runoff.

Classification of the ground cover of Al-Sharhani Basin and its secondary basins:

The land cover varies over time due to the change in the human need for the land.

Table (4) *Distribution of (CN) values in the studied drainage basins*

Percentage for each basin				٪rate	Total area	CN value
B3	**B2**	**B1**	**Alsharhani**			
0.79	9.88	1.65	11.68	22.41	195.4	70
0.55	22.10	1.78	19.25	7.46	65.38	84
0.91	26.71	0.89	5.23	15.88	139.12	86
1.63	27.53	2.13	9.83	23.71	208.18	88
1.77	28.26	18.82	14.47	30.41	266.35	94
0.07	0.3	0.12	0.1	0.13	1.22	100

This table is based on maps.(1,2,3,4)

The basis of the (CN) curve tables and according to the natural characteristics of the studied basins, and it is clear from Table (5) that there are five types of river basin cover.

Table (5) *Classification of land cover and land uses in Al-Sharhani Basin and its secondary basins*

rate	area	Class	basin
15.6	21.38	agricultural land	
28.9	39.40	Depressions	
25.1	34.12	sandy soils	in Al-Sharhani main basin
15.6	21.25	rocky lands	
14.8	20.13	Soil the stomachs of the valleys	
10.1	3.61	agricultural land	
34.2	12.28	Depressions	
35.5	12.80	sandy soils	B1
14.2	5.11	rocky lands	
6.0	2.18	Soil the stomachs of the valleys	
18.9	18.35	agricultural land	
28.3	27.34	Depressions	
29.3	28.25	sandy soils	B2
19.8	19.14	rocky lands	
3.7	3.62	Soil the stomachs of the valleys	
8.6	0.31	agricultural land	
33.6	1.21	Depressions	
30.8	1.11	sandy soils	B3
14.4	0.52	rocky lands	
12.6	0.45	Soil the inside of the valleys	

This table is based on the map (5) and the view of Al-Sharhani basin using Arc GIS 10.8

Conclusions

This study has reached the following:

1- The increase in (CN) values contributed to the events of water run-off after rains and the low percentages of water penetrating into the subsurface layers. Here, the permeability rates reached according to total (CN) values for Al-Dorssa Al-Sharhani basins (19.21) and (18.53) for the basin (B1) and (18.49) for basin (B2) and (20.22) for basin (B3).
2- Soils were divided into two groups: Class (B) and Class (C).
3- The expressive values were 6 that ranged between (70) for areas with the most water permeability and the least abile to generate surface runoff, and between (100) for areas that are not filtered for water, where the rate of (CN) in the first, second and third basins reached (94.5) while it reached in the fourth basin (84).

Recommendations

1- The Ministry of Water Resources, the Ministry of Environment and the Ministry of Agriculture have to build dams on the Al-Sharhani basin and its secondary basins.

2- The relevant authorities are recommended to establish large and small water collectors distributed on the lands of the basin to store the water falling during the winter .

References

Abraham, S., Huynh, C., & Vu, H. (2019). Classification of soils into hydrologic groups using machine learning. Data, 5(1), 2 .

Al-Ghurabi, H. J. A. (2021). Hydrological analysis of the wadi network and determination of dam construction sites and their economic investments in eastern Wasit Governorate using GIS. (PhD unpublished). University of Baghdad, College of Arts .

Al-Jubouri, A. H. H. (2018). estimating the annual water revenue using the (CN - SCS) method based on remote sensing applications - Spatial Information Systems for Wadi Abu Khashab in northern Iraq, Department of Applied Earth Sciences. TJPS .(9)

Ali A. Kazem , Miqdam T. Chaichan, Hussein A. Kazem, Dust effect on photovoltaic utilization in Iraq: Review article, Renewable and Sustainable Energy Reviews 37 (2014) 734–749.

Asling. (1983). Soil Physics Terminology Inter, Soc. Of Soil Sic, Ame .

Nachiappan, R. (1998). CS (AR)-37/98-99: Study of lake Nainital-groundwater interaction using isotope techniques. Retrieved from .

Ali A Alwaely, Hanan N Al-qaralocy, Kadhem A Al-Asadi, Miqdam T Chaichan, Hussein A Kazem, The environmental aftermath resulted fromchemical bombardment of Halabj Territory for the period 1988-2014, International Journal of Scientific & Engineering Research, Volume 6, Issue 9, September-2015.

Salih, S. M. (2021). Modeling Flood Risks in the City of Mosul. (Master). University of Mosul, the College of Education for Human Sciences .

Ali A Kazem Al-Waeli and Osamah K Alsharifiy, (2020). A Study Some Physical and Chemical Properties of Khuweisah Valley Basin East Of Misaan Governorateby Using Rs&Gis. Journal of Physics & Optics Sciences, Volume 2(1): 1-6.