APPLICATION THE DRIS EQUATION TO ASSESS THE NUTRIENT STATUS OF DUKAN AND DUHOK LAKES IN NORTHERN OF IRAQ

Dalshad A. Darwesh[1] **Yahya A. Shekha** **Janan J. Toma**

Environmental Science Department- College of Science, Univ. of Salahaddin, Erbil, Iraq.

[1] Corresponding author: dadazeezdarwesh72@gmail.com

ABSTRACT

This investigation was conducted to study the nutrient status of different lakes and to determine the productivity status of lakes by comparing the results of DRIS approach with the lakes productivity equations. Data for application of DRIS and TSI equations were collected from previous studies for Dukan and Duhok Lakes that conducted at different studies periods while water samples were taken and analyzed during 2013. The results of nutrient index showed that the Dokan Lake was more balance or adequate status of nutrient in 1980 compared with 2014, because there imbalance of nutrients indices recorded lower value (193.60) in 1980 compared with 2014 which attained (413.34). However data analysis was revealed that the lower value of NBI (129.52) was recorded in 2013 in comparison to the higher value NBI in 2000 in Duhok Lake. The DRIS also computed an overall index, which is the sum of the absolute sum of all DRIS indices, the lesser NBI the imbalance among nutrient referred to more productivity. In general the result indicate that nutrient index and nutrients imbalance index showed more balance in Dukan Lake in previous period in comparison with the recent period, vice versa for Duhok Lake. From TSI value revealed that the productivity of Dukan Lake decreased from (56.41) to (53.07) during 1980 and 2014, while the productivity of the Duhok Lake increased from (30.11) to (32.63) during 2000 to 2013.

Key words: DRIS, Nutrient status, TSI, Dukan and Duhok Lakes.

INTRODUCTION

The trophic status referred to the level of productivity in a Lakes as measured by phosphorus, algal abundance, and depth of light penetration. Trophic status in clean lentic water based on amount of biological productivity occurring in the water (Chandrashekar *et al*., 2014). High nutrient concentrations in aquatic ecosystems can results in increased primary production (Dodds and Whiles, 2010). Higher primary productivity is not necessarily a predictor of poor ecological condition as it is natural for Lakes to shift from lower to higher trophic states but this is a slow process (Sullivan and Reynolds, 2004). Bioavailable nutrients, are generally thought to control primary production, or

Received: 17/1/2016
Accepted: 23/1/2017

organic matter production, in lakes and reservoirs, light, temperature and micronutrients are important factors contribute to primary production (Novotny and Olem, 1994). As nutrient concentration and primary production increase, the water body classification can change from oligotrophic, mesotrophic, eutrophic and finally hypertrophic (Mahesh *et al*., 2014). Using the index, one can get a quick idea about the extent of productivity of a Lake (Sharma *et al*., 2010).The enrichment of bodies of water is associated with increased primary production and the occurrence of episodes of excessive development of algae or aquatic macrophytes, which may affect the use of the water for different purposes and for the protection of aquatic life (Santos *et al*., 2014). Trophic state index (TSI) that retains the expression of the diverse aspects of the trophic state found in multi-parameter indices yet also has the simplicity of a single parameter index, for water quality assessment of impounded water bodies was proposed by (Carlson, 1977). Carlson's trophic state index can be computed from any of the three interrelated water quality parameters: Secchi disk depth (SDD), chlorophyll-*a* concentration (Chl *a*), and total phosphorous measurement (TP). The index has been widely accepted owing to its calculation simplicity and ability to communicate between researchers, government agencies, and local community residents (Cheng *et al*., 2001).

The diagnosis and recommendation integrated system (DRIS) is a recent approach for interpreting plant tissue analysis indices. The DRIS proposed by (Beaufils, 1973) has been used The DRIS index scale that results from those calculations is continuous and easy to be understood (Walworth *et al*., 1986). This model is designed to determine when the nutrient contents of crops are excessive (positive indices), adequate (zero indices) or deficient (negative to determine the balance of N, P, K and S in wheat plant. Also many investigators has been studied DRIS approach like, (Sevenson *et al*., 1988; Hanson, 1981; Mackay *et al*., 1987; Al-Khafaji, 1993; Caldwell, 1994; Soltanpour *et al*., 1995; Esmail *et al*., 1999; Sultan, 2005; Darwesh, 2007). Most of these study were carried out on plant and soil, while the DRIS equation has not applied to study the nutrients status of water body in Kurdistan region, thus the objectives of this investigation was to evaluate the nutrient status of different lakes and to determine the productivity of lakes by comparing the results of DRIS approach with the lakes productivity equations.

MATERIALS AND METHODS

Data collection

Data for application of DRIS and TSI equation were collected from previous studies for Dukan Lake (Shaban, 1980; Goran, 2014), for Duhok Lake from (Al-Nakshbandi, 2000), while samples were collected and analyzed for Duhok Lakes (during 2013).

Samples collection

Water samples were taken in a clean polyethylene bottle from Duhok reservoir in different seasons during 2013 at three sites. Water transparency was measured by using Secchi disk. Total phosphate was measured by using persulphate digestion method, while chlorophyll- *a* determined by using acetone extraction procedure the absorbance were measured by spectrophotometer, total dissolved nitrogen using potassium persulphate ($K_2S_2O_8$) as described in (APHA, 1998; Bartram and Balance, 1996).

Study area

The Dohuk dam is an earth-fill embankment dam (latitude: 36º 52′ 33″ N; longitude: 43º 00′ 13″ E). It was built on the Dohuk River just north of Dohuk city, Iraq. The dam was completed in 1988 with the primary purpose of providing water for irrigation. It is 60 m height and can withhold 52,000,000 m^3 of water. The dam has a bell-mouth spill way with a maximum discharge of 81 m^3/s. maximum length of reservoir is 4km and maximum width is about 1.7km, with maximum depth of 60m (Shekha *et al*., 2013) (Figure 1).

The Dukan Dam is a multi-purpose concrete arch dam in Sulaymaniyah Governorate, Iraq (latitude: 35º 57′ 15″ N; longitude: 44º 57′ 10″ E). It impounds the Lesser Zab River, thereby creating Dukan Lake.

The dam was built between 1954 and 1959 as a multi-purpose dam to provide water storage, irrigation and hydroelectricity. It is 116.5m height and can withhold 6,970,000,000 m^3 of water. The catchment area is 11,690 km^2 and surface area is about 270 km^2 (Goran, 2014) (Figure 1).

These equations (equation 1, 2, 3 and 4) were originally based on Carlson trophic static indices (Carlson, 1977). (Kratzer and Brezonik, 1981; Popovicova and Celi, 2009; Rahul *et al*., 2013).

$$TSI\ (SD) = 60.0 - 14.41 * \ln(SD) \quad [1]$$

$$TSI\ (TP) = 14.42 * \ln(TP) + 4.15 \quad [2]$$

$$TSI\ (Chl) = 30.6 + 9.81 * \ln(Chl) \quad [3]$$

In which The TSI based on TN data was calculated using (Zbierska *et al*., 2015) equation:

TSI (TN) = 54.45 + 14.43 ∗ ln(TN) [4]

Carlson's trophic state index (CTSI) = [TSI (TP) +TSI (CA) +TSI (SD)]/4

Where SD = Secchi Depth (m), TP = Total Phosphorous (μg/l), TN = Total Nitrogen, Chl = Chlorophyll (μg/l).

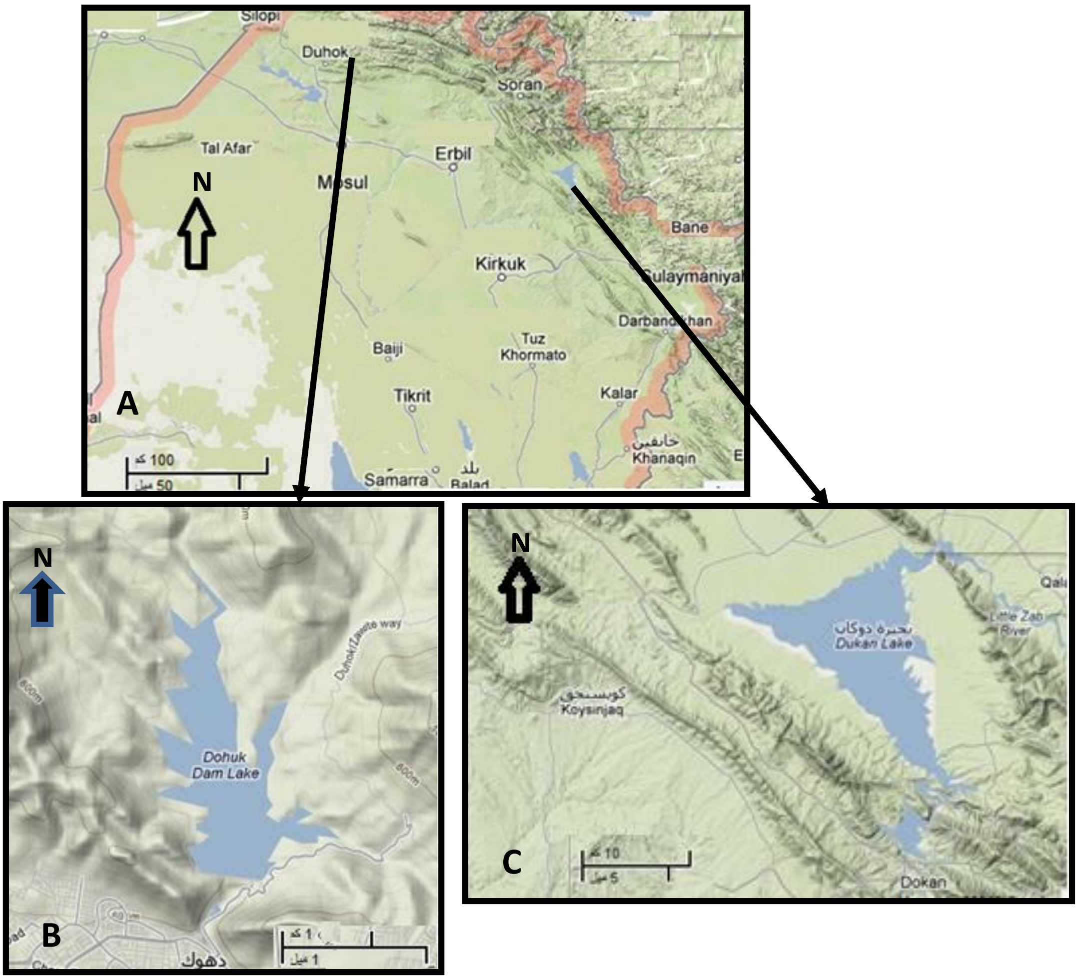

Figure 1: Show map of: A- Northern part of Iraq, B- Duhok dam in Duhok city, C- Dukan dam in Sulaimanyah Governorate (Google Earth)

The nutrients indices were calculated by using the following index equations by (Hallmark *et al*., 1987):

N index= [f (N/P) +f (N/K) +f (N/Ca) +f (N/Mg) +f (N/Na) +f (N/S) +f (N/Chl)]/n

P index= [-f (N/P) +f (P/K) +f (P/Ca) +f (P/ Mg) +f (P/Na) +f (P/S) +f (P/Chl)]/n

K index= [-f (N/K) -f (P/K) +f (K/Ca) +f (K/Mg) + f (K/Na) +f (K/S) +f (K/Chl)]/n

Ca index= [-f (N/Ca) -f (P/Ca) -f (K/Ca) +f (Ca/Mg) + f (Ca/Na) +f (Ca/S) +f (Ca/Chl)]/n

Mg index= [-f (N/Mg) -f (P/Mg) -f (K/Mg) -f (Ca/Mg) +f (Mg/Na)+f (Mg/S) +f (Mg/Chl) /n

Na index= [-f (N/Na) -f (P/Na) -f (K/Na) -f (Ca/Na) -f (Mg/Na) +f (Na/S) +f (Na/Chl)]/n

S index= [-f (N/S) -f (P/S) -f (K/S) -f (Ca/S) -f (Mg/S) -f (Na/S) +f (S/Chl)]/n

Chl.index= [-f (N/chl) -f (P/chl) -f (K/chl) -f (Ca/chl) -f (Mg/chl) -f (Na/chl) -f (S/Chl)]/n

The functions were calculated by using the following equations:

f(A/B)=[(A/B)/(a/b) -1] (100/CV)when A/B>a/b,

f(A/B)= [1- (a/b)/(A/B)] (100/CV)when A/B<a/b,

Where:-A/B= Nutrient ratio for all sample tissue except norm treatments.

a/b= Nutrient ratio for norm treatments

CV=coefficient of variation of data base nutrient ratio

n= is the number of function values

RESULTS AND DISCUSSION

The data analysis in table (1) refers to nutrient index and nutrient imbalance index, the indices of NO_3, NH_4, P, K, Na, Ca, Mg, S and Chl *a* were increased from (-1.25, 46.35, -0.47, -16.36, -25.71, -0.41, 6.06, 12.35, -0.57) to (-115.30, 46.77, 5.12, -2.15, 10.29, 3.45, 11.26, 35.58 and 4.97) respectively, for Duhok Lakes between 2000 and 2013. While the nutrients indices for Dukan Lake were increased from (62.67, 19.06, -6.02, 14.71, -1.48, -0.47, 0.36) to (87.01, 43.55, 29.48, 3.95, 30.14, 10.18) for NO_3, NH_4, P, Ca, Mg, S and Chl *a* respectively, whereas the K and Na indices decrease from -16.26 and -72.57 to -22.82 and -183.85. According to the result of nutrient index the Dukan Lake shows more balance or adequate status of nutrient in 1980 in comparison with 2014, because the imbalance nutrients index data was recorded lower value (193.60) in 1980 compared with 2014 which attained (413.34). However the data analysis in the same table revealed that the lower value of NBI (129.52) was recorded in 2013 in comparison to the higher value NBI in 2000 in Duhok Lake. The DRIS also computed an overall index, which was the sum of the absolute sum of all DRIS indices, the lesser NBI the imbalance among nutrient referred to more productivity. In general the result indicated that nutrient index and nutrients imbalance index showed more balance in Dukan Lake in previous period in comparison with the recent period, vice versa for Duhok Lake. The TSI data in table (2) revealed that the productivity of Dukan Lake decreased from (56.41) to (53.07) from 1980 to 2014 while the productivity of the Duhok Lake increased from (30.11) to (32.63) during 2000 to 2013. The obtained values were compared with Carlson's trophic state classification criteria (Table 2). Results of TSI indicate that Dukan Lake classified as eutrophic and Duhok Lake as mesotrophic. These results may be due to human activities around both lakes, especially, Dukan Lake was more effected by these pollutant because of their larger surface area which exposed to pollutant from different sources. Toma (2000) and Goran (2014) reported that pollutant sources in Dukan Lake mainly came from anthropogenic activities such as agriculture land, sewage disposal and tourism. Same results and reasons were noted by Al- Nakshabandi (2000) for Duhok Lake, which led to increase in nutrients content and decrease in water quality for both lakes. Hou *et al*. (2013), Barki and Singa (2014) were mentioned that human influences a lake by increasing content of plant nutrients, primary nitrogen and phosphorus. These nutrients can enter the lake through agricultural land, sewer, or wastewater which can cause over enrichment.

Table 1. The nutrients index and nutrient imbalance index of Dokan and Duhok Lakes at different periods

Lakes	NO_3I	NH_4I	PI	KI	NaI	CaI	MgI	SI	Chl I	NBI
Duhok 2013	-21.25	46.35	-0.47	-16.36	-25.71	-0.41	6.06	12.35	-0.57	129.52
Duhok 2000	-115.3	46.77	5.12	-2.15	10.29	3.45	11.26	35.58	4.97	234.89
Dokan 2014	87.01	43.55	2.37	-22.82	-183.8	29.48	3.95	30.14	10.18	413.34
Dokan 1980	62.67	19.06	-6.02	-16.26	-72.57	14.71	-1.48	-0.47	0.36	193.60

Table 2. TSI values for Dukan and Duhok Lakes with Carlson's Trophic State Classification Criteria

Lakes	Average TSI values (TP+ SD+ TN+ Chlorophyll- a)	TSI scales	Carlson's TSI Classification Criteria
Dukan 1980	56.41	<30	Oligotrophic
Dukan 2014	53.07	30- 50	Mesotrophic
Duhok 2000	30.11	50- 60	Light Eutrophic
Duhok 2013 (*)	32.63	60- 70	Moderate eutrophic
		70- 100	Hyper eutrophic

* data obtained from samples collected and analyzed, others data were collected from previous studies.

REFERENCES

Al- Nakshbandi, I. Z. R. 2000. A phycological study on Duhok impoundment its main watershed. Ph. D. Dissertation- Duhok University-Iraq. 143pp.

Al-Khafaji, S. K. M. 1993. Interrelation of magnesium with zinc and magnesium in plant nutrition and productivity of tomato and cucumber plants under heated plastic house. Ph. D. Dissertation. University of Baghdad- Iraq.

(A.P.H.A.) American Public Health Association. 1998. Standard Methods for the Examination of Water and Wastewater. 20th Ed. A.P.H.A., 1015 Fifteenth Street, NW, Washington, DC. 20005-2605.

Barki, D. N. and P. Singa. 2014. Assessment of trophic state of Lakes in terms of Carlson's trophic state index. *Inter. J. of Innov. Res. in Sci., Eng. and Tech*. 3(7): 14297- 14302.

Bartram, J. and R. Balance. 1996. Water Quality Monitoring (a practical guide to the design and implementation of freshwater quality studies and monitoring programs). United Nation Environmental Programme- UNEP and WHO. E and FN Spon, Chapman and Hall. UK. 383pp.

Beaufils, E. R. 1973. Diagnosis and recommendation integrated system (DRIS). A general scheme for experimentation and calibration based on principles developed from research in plant nutrition. *Soil Sci. Bull. Univ. Natal*. 1: 1-132.

Caldwell, J. O., M. E. Sumner and C. S. Varina. 1994. Development and testing of preliminary foliar DRIS norms for onions. *Horticul. Sci*. 29: 1501-1504.

Carlson E. R. 1977. A tropical state index for Lakes. *Limnology and oceanog*. 22(2).

Chandrashekar, C., K.V. Lokesh, H. Pushpa and G. Ranganna. 2014. Studies on the assessment of trophic status of Lakes. *Inter. J. of Current Microbio. and. Appl. Sci*. 3(6): 245-254.

Cheng, K. S. and T. C. Lei. 2001. Reservoir trophic state evaluation using landsat TM images. *J. of the American Water Resources Association*, 37(5): 1321-1334.

Darwesh, D. A. 2007. Role of supplemental irrigation and fertilizer treatments on yield and nutrients balance in wheat by using modified DRIS. Ph. D. Dissertation. University of Salahaddin/ Erbil-Iraq.

Dodds, W. K. and M. R. Whiles. 2010. Freshwater Ecology: Concepts and environmental applications of limnology. 2nd Ed. Academic Press is an imprint of Elsevier. USA.811pp.

Esmail, A. O., K. K. Hamad and M. F. Yadgar. 1999. Effect of Mg/Ca ratio in irrigation water on yield and quality of *Chick pea*. *Zanko J*. 11(2): 11-17.

Goran, S. M. A. 2014. Ecological study on Dukan Lake with particular reference to bioaccumulation of some heavy metals and PAHs in fish and Gull tissues. Ph. D. Dissertation. Salahaddin University, Erbil- Iraq.

Hallmark, W. B., C. J. deMooy and J. Pesek. 1987. Comparison of two DRIS methods for diagnosing nutrient deficiencies. *J. of Fertil*. 4(4): 150-158.

Hanson, R. G. 1981. DRIS evaluation of N, P, K status of determinant soybeans in Brazil. *Soil Sci. and Plant Nutrit*. 12: 933-948.

Hou, D., J. He, C. Lu, Y. Sun, F. Zhang and K. Otgonbayar. 2013. Effect of environmental factors on nutrients release at sediment-water interface and assessment of trophic status for a typical shallow Lake, Northwest China. *The Sci. World J*. http://dx.doi.org/10.1155/2013/716342.

Kratzer, C. R. and P. L. Brezonik. 1981. A Carlson- type trophic state index for nitrogen in Florida Lakes. *Water Resources Bull*. 17: 713- 715.

Mackay, D. C., J. M. Carefoot and T. Entz. 1987. Evaluation of the DRIS procedure for assessing the nutritional status of potato (*Solanum tuberosum* L.). *Soil Sci. and Plant Anal*.18: 1331-158.

Mahesh, S., H. Strikantha, K. S. Mohan and S. Vathsala. 2014. Eutrophication assessment for the Dantaramakki Lake of Chikmagalur city using GIS technique. *Inter. J. of Chem. Tech. Res*. 6(1): 440- 449.

Novotny, V. and H. Olem. 1994. Water Quality: prevention, identification, and management of diffuse pollution. John Wiley and Sons, New York, NY.

Popovicova, J. and D. E. F. Celi. 2009. The trophic status of Prairie creek reservoir: Implications for resource management. *Proceed. of Indiana Acad. of Sci*. 118(1): 1- 12.

Rahul, U., P. K. Arvind and S. K. Upadhyay. 2013. Assessment of Lake water quality by using Palmer and trophic state index- a case study of upper Lake, Bhopal, India. *Inter. Res. J. of Environ. Sci*. 2(5): 1-8.

Santos, J. C. N., E. M. Andrade, J. R. A. Neto, A. C. M. Meireles and H. A. Q. Palacio. 2014. Land use and trophic state dynamics in a tropical semi- arid reservoir. *Rev. Ciencia Agron*. 45(1): 35- 44.

Sevenson, G., A. Kimberley and M. O. Can. 1988. DRIS improve diagnosis nutrient deficiency in *Pinus radiate*. *J. of forest Sci*. 18: 33-42.

Shaban, A. A. 1980. An ecological study on phytoplankton of Dokan Lake. M. Sc. Thesis. University of Sulaimaniyah, Iraq.

Sharma, M. P., A. Kumar and S. Rajvanshi. 2010. Assessment of trophic state of Lakes: case of Mansi Ganga Lake in India. *Hydro Nepal*. 6: 65- 72.

Shekha, Y. A., H. M. Ismael and A. A. Ahmed. 2013. Bacteriological and mycological assessment for water quality of Duhok Reservoir. *Jordan J. of Biol. Sci. (JJBS)*. 6(4):1-10.

Soltanpour, P. N., M. J. Malakouti and A. Ronaghi. 1995. Comparison of diagnosis and recommendation integrated system and nutrient sufficient range of corn. *Soil Sci. Soc. of Amer. J*. 59: 133–139.

Sullivan, P. E. and C. S. Reynolds. 2004. The Lakes Handbook: Limnology and limnetic ecology. Blackwell Publishing Company. 699pp.

Sultan, M. Y. 2005. Effect of bacterial inoculation and chemical fertilizers on lentil *Lens culinaris* by using the diagnosis and recommendation integrated system (DRIS). Ph. D. Dissertation. University of Mosul- Iraq.

Toma J. J. 2000. Limnologicl study of Dokan Lake, Kurdistan region, Iraq. M. Sc. Thesis, University of Salahaddin-Erbil-Iraq.

Walworth, J. L., M. E. Sumner, R. A. Isaac and C. O. Plank. 1986. Preliminary DRIS norms for alfalfa in the Southeastern United States and a comparison with the Midwest norms. *Agro. J. Madison*. 78: 1046-1052.

Zbierska, J., A. E. Lawniczak and A. Zbierska. 2015. Changes in the trophic status of Lakes Niepruszewskie (Poland). *J. of Ecolog. Eng*. 16(4): 65- 73.

تطبيق معادلة دريس لتقويم حالة المغذيات لبحيرتي دوكان ودهوك شمال العراق.

دلشاد عزيز درويش [1] **يحيى أحمد شيخه** **جنان جبار توما**

قسم علوم البيئية/ كلية العلوم /جامعة صلاح الدين- أربيل، العراق

[1] المسؤول عن النشر: dadazeezdarwesh72@gmail.com

المستخلص

تم اجراء هذا البحث لدراسة حالة العناصر الغذائية وتحديد الانتاجية لبحيرتي دوكان ودهوك بوساطة مقارنة النتائج باستخدام نظام التشخيص والتوصيات المتكاملة مع نتائج معادلات الانتاجية لتطبيق معادلات DRIS و TSI. تم جمع البيانات من الدراسات السابقة التي اجريت على بحيرتي دوكان ودهوك في فترات دراسية مختلفة, مع أخذ نماذج المياه لبحيرة دهوك وتحليلها خلال 2013. اظهرت النتائج ان ادلة العناصر الغذائية في بحيرة دوكان كانت اكثر توازنا في سنة 1980 مقارنة بسنة 2014 وذلك بسبب عدم توازن ادلة العناصر الغذائية حيث سجلت ادنى قيمة وهي 193.60 لأدلة عدم توازن العناصر الغذائية في 1980 مقارنة بعام 2014 التي بلغت 413.34 ، واظهر تحليل النتائج ايضا بان ادنى قيمة لعدم التوازن للعناصر الغذائية كانت 129.52 حيث سجلت في 2013 مقارنة بأعلى قيمة لعدم التوازن الغذائي في 2000 لبحيرة دهوك. في نظام التشخيص والتوصيات المتكاملة يتم حساب الدليل العام او دليل عدم التوازن الغذائي وهي مجموع القيم المطلقة للدليل بين العناصر حيث تشير الى اعلى انتاجية. بشكل عام نتائج ادلة العناصر وادلة عدم توازن العناصر الغذائية اظهرت توازن اعلى للعناصر في بحيرة دوكان في الفترات السابقة مقارنة بالفترات الحديثة والعكس صحيح في بحيرة دهوك. من خلال قيمة دليل الحالة الغذائية (TSI) اظهرت النتائج بان الانتاجية في بحيرة دوكان انخفضت من 56.41 الى 53.07 خلال سنوات 1980 الى 2014، بينما ازدادت الانتاجية في بحيرة دهوك من 30.11 الى 32.63 خلال المدة من 2000 الى 2013 .

كلمات مفتاحية: دريس، حالة المغذيات، دليل حالة المغذيات، بحيرتي دوكان ودهوك.