

Assessment of Spatial and temporal variability of surface water quality of Irrigation Canals. A case study of Trimmu Head Canals under Chenab River area

Asif Ali ^a

^aDepartment of Agricultural Engineering, Bahauddin Zakariya University, Multan, Pakistan
Corresponding Email: jamasif5775@gmail.com

Abstract

Pakistan agriculture and industrial sector is mostly dependent on water and having the largest irrigation system in the world. In order to maintain and secure the environment and ecosystem, engrossment must be paid to water quality and resources management. The purpose of this research was to evaluate surface water quality in perennial and non-perennial canal from head to tail with spatio-temporal changes. The data of 10 standard monitoring sites from main canals of Trimmu Head was collected and analyzed during 2015 to 2018. The result indicated that most of the water quality parameters were in safe range according to standards range of water quality parameter but all parameters except pH were affecting and decreasing quality year by year and were found and adverse effects were found at the tail of Multan Branch canal. Maximum parameters were found at increasing threat level in head to tail. Most of the industries, agricultural and sewerage system is discharged into perennial canals due to continuous flow. The adverse effects in non-perennial canal was observed significantly neglected than perennials canals. The quality of water was lower at the tail of canals due to addition of effluent discharge of towns and industries.

Keywords: Surface water, Canal, Head, Mid, tail

Introduction

Water is a natural gift of God to all human beings, plants and animals. The presence of water at any place indicate whether life exist there or not. In this developed era, water demand is increasing day by day. Water play a vital role in economy of any country and in hydrological

cycle to maintain ecosystem (Jia et al. 2019; Wu et al., 2013). Water scarcity is one of the major cause of environmental problem by which water quality and quantity both affected, due to more usage of water at industrial, Agricultural and domestic level (Arslan et al., 2017; Bibi et al., 2016). The increasing of population at more rate cause more industrial revolution to meet the requirements, incorrigibly management of water resources cause resources threats and excessive consumption of water at irrigation and industrial level cause bad quality water due to presence of deleterious and undesirable material (Sener et al., 2013; Yousefi et al., 2013; Saleh et al., 2018). The effect of pesticides, fertilizers and industrial baleful material mixing in water effect on aquatic life and human beings health (Toan et al., 2013; Ljung et al., 2009).

The land of Punjab is dependent on three source of water i.e., groundwater, surface water and rainfall. Surface water of Indus Basin Irrigation System is the largest source of irrigation water. Where groundwater is the second largest source for irrigation purpose in Punjab (Javed et al., 2015). According to Farm Water Management wing of Punjab Irrigation Department, the total water of IBIS is about 144.2 MAF. According to Water Accord 1991, total surface water allocation that is delivered to Punjab is 55.54 MAF. After canal evaporation, percolation and seepage losses, 37 MAF water is available at mogha of canal. Due to poor standing condition of conveyance system in Pakistan, more than 40 % of canal water is lost between farmer's fields and outlet/mogha. The amount of water about 20 to 25% is lost due to uneven fields condition. At farm gate, 26 MAF water is available for best utilization, that is very low amount of water to complete the need of irrigation for agricultural purpose in Punjab due to presence of rich fertile and productive soil. The crop water requirement (CWR) in Punjab is about 65 MAF. To complete these needs, farmer depend on groundwater extraction through tub wells that is about 33 MAF and rainfall amount per year is 7 MAF. After the field losses, 45 MAF water is available in every year for CWR. Whether the total CWR is about 65 MAF. Just 2.99 Million farmers are getting benefits from 55 completed projects of On Farm Water Management department of Punjab. Therefore, moorland area is increasing day by day due to improper management of water resources. Due to resources

scarcity, instead of water about 32 MAF water dropped into Arabian Sea instead of 10 MAF that is standardized amount according to international rules and regulation. Pakistan is facing water scarcity due to shortage of resources like Dams.

Resources majority and reservoirs are the main part of the ecosystem and life cycle of plants, animals, fisheries and humans (Mishra et al. 2019). Anthropogenic activities like industrial discharge, agricultural runoff and sewerage runoff during more rainfall cause downgrading of water quality that effect both aquatic and living thing (Teshome 2020; Varol 2020). Therefore, it is necessary to check and keep the record of pollutants of industry, sewerage and its sources that deteriorate water quality (Tibebe et al. 2019; An-bazhagan 2018). Because sewerage system of colonies is mostly interconnected with waterbodies. Physical, chemical and biological characteristics of aquatic ecosystem for appraisalment of spatio-temporal difference of surface water flow is necessary to assess the presence of metals and other dangerous parameters (Varol 2012; Hamlat et al. 2013). The main objective of study was to analyze the spatial and temporal variability of surface water quality at head, mid and tail of perennial and non-perennial canals.

Materials and Method

Study area

The study area consists of mainly two main canals and it stretches in four district of Punjab, Pakistan i.e., Jhang, T.T. Singh, Khanewal and Multan. The monitoring site is indicated on Trimmu Head Jhang, from which perennial and non-perennial canals off-take from same reference point. The HML (perennial canal) and RC (non-perennial) offtake from left side and right side of Trimmu H/W respectively. The common point of mentioned black lines indicate as a reference point Trimmu H/W. The left side canal offtakes as name HML in Jhang and T.T. Singh. Then connected to sidhnai H/W named as Sidhnai canal that passes from Khanewal, at the end Multan Branch passes from district Multan (Ali et al., 2020). The discharge of these canals gradually decreases with spatial-temporal variability. The land of these canals is historically fertile and rich by production with different types of crops. The map of the study area is shown in fig. 1.

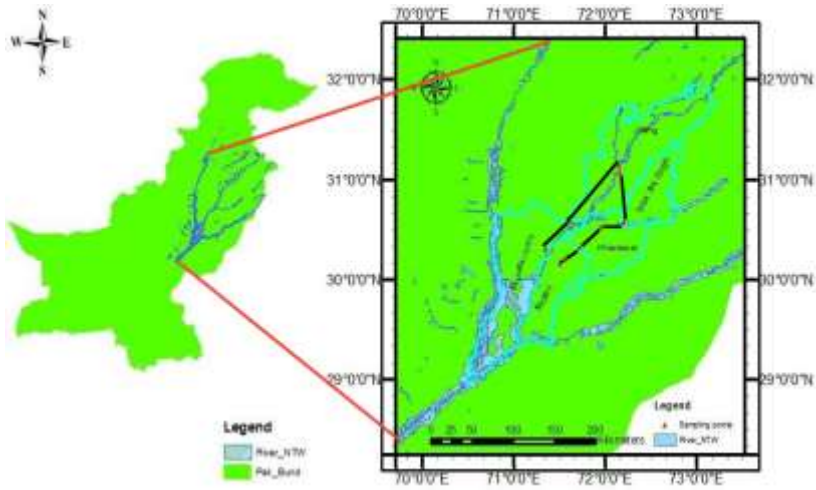


Fig. 1. Map area of Trimmu Head canals on IBIS

Datasets and Methodology

The surface water data was collected from 14 monitoring sites by Land Reclamation Department, according to standard protocol of Punjab Irrigation Department. The data was collected for consecutive four year from 2015 to 2018, with interval of one month. The address of sampling points were taken as a true reference at head, mid and tail of each canal/headworks. The characteristics of both Trimmu head canals in study region are represented in Table 01. Samples were analyzed for Ca, Mg, Na, K, Total cation, HCO_3 , Cl, SO_4 , pH, EC and SAR. The different analysis were investigated at head, mid and tail of all canals with the help of scattering charts at 10 consecutive standard monitoring sites except obscure point. The eight sample were collected from adjoining perennials canals (HML, SC and MB canals) and three samples from Rangpur canal (non-perennial). In Table 02, the remarks bolded monitoring sites were taken as common points, due to tail of previous canals and head of next canal. According to Food Agricultural Organization, With spatio-temporal variability, discharge of every canal decreases due to diversion/ usage of surface water to the fields by farmers.

Sampling Characteristics and Standard ranges of Water quality parameters

Standard ranges of parameters (Ca, Mg, Na, K, Total cation, HCO₃, Cl, SO₄, pH, EC and SAR.) followed by Food Agricultural Organization are shown in Table 02.

Table 01: Details of sampling size surface water along with coordinates of Treamu Head Canal (Year: 2015-2018)

Sr. No.	Source	Discharge Cs	Address of Sampling Point	Remark	Elevation NSL (ft)	Month	Longitude	Latitude
1-SWM	Trimmu H/Work		At H/Works	H/W	452	Feb April June Aug Oct Dec	72.1472	31.1446
2-SWM	Haveli Mainline	5170	Head at Trimmu Head Works	H	463	Feb April June Aug Oct Dec	72.1519	31.1438
3-SWM	Haveli Mainline		Mid at Haveli Bahadur Shah	M	486	Feb April June Aug Oct Dec	72.173	31.0659
4-SWM	Haveli Mainline		Tail at Haveli Main Line	T	449	Feb April June Aug Oct Dec	72.2079	30.5848
5-SWM	Sidhnai Headworks		At Sidhnai H/Works	H/W	428	Feb April June Aug Oct Dec	72.1574	30.5715
6-SWM	Sidhnai Canal	4005	Head at Sidhnai H/Works	H	392	Feb April June Aug Oct Dec	72.154	30.5693
7-SWM	Sidhnai Canal		At Chooper Hatta	M	402	Feb April June Aug Oct Dec	71.9557	30.5313
8-SWM	Sidhnai Canal		At Pull Rangoo	T	417	Feb April June Aug Oct Dec	71.7254	30.3245
9-SWM	Multan Branch	775	Head at Pull Rangoo	H	417	Feb April June Aug Oct Dec	71.7233	30.3214
10-SWM	Multan Branch		Near Natural Gas Power Plant	M	401	Feb April June Aug Oct Dec	71.5601	30.2049
11-SWM	Multan Branch		Tail of Multan Branch	T	392	Feb April June Aug Oct Dec	71.5041	30.1617
12-SWM	Rangpur Canal	2710	Head at Trimmu Head Works	H (Non-Perennial)	452	Feb April June Aug Oct Dec	72.1416	31.1458

Table 02: Standard ranges of surface water quality parameters adopted by FAO

Water parameter	Symbol	Unit ¹	Usual range in irrigation water	
SALINITY				
Calcium	Ca ⁺⁺	me/l	0 – 20	me/l
Magnesium	Mg ⁺⁺	me/l	0 – 5	me/l
Sodium	Na ⁺	me/l	For Surface Irrigation (3-9) or 0 – 40	me/l
Salt Content				
Electrical Conductivity	EC _w	dS/m	0 – 3	dS/m
Carbonate	CO ₃ ⁻³	me/l	0 – .1	me/l
Bicarbonate	HCO ₃ ⁻	me/l	0 – 10	me/l
Chloride	Cl ⁻	me/l	For Surface Irrigation (4-10) or 0 – 30	me/l
Sulphate	SO ₄ ⁻⁻	me/l	0 – 20	me/l
Total Dissolved Solids	TDS	mg/l	0 – 2000	mg/l
NUTRIENTS				
Potassium	K ⁺	mg/l	0 – 2	mg/l
Nitrate-Nitrogen	NO ₃ -N	mg/l	0 – 10	mg/l
Ammonium-Nitrogen	NH ₄ -N	mg/l	0 – 5	mg/l
Phosphate-Phosphorus	PO ₄ -P	mg/l	0 – 2	mg/l
MISCELLANEOUS				
Acid/Basicity	pH	1–14	6.0 – 8.5	
Sodium Adsorption Ratio	SAR	me/l	0 – 10	me/l

Results and Discussions

The surface water samples were analyzed for Mg, Na, K, Total cation, HCO₃, Cl, SO₄, pH, EC and SAR. The data was collected for 24 month of 4 years to check quality whether trend increasing or decreasing surface water for irrigation purpose. All parameters were investigated against both perennial and non-perennials canals. Magnesium parameter is increasing from head to tail in all consecutive years as

shown in figure 02. In Figure 03, sodium parameter values increases from Trimmu head to tail of HML and decreasing pattern was observed against Rangpur canal from head to tail. But potassium parameter remain within safe value zone and increasing at head of RC and decreasing at its tail as shown in figure 04.

Total cation and Bicarbonate parameters trend are increasing from head to tail within limit range as shown in figure 05-6. But values of both parameters were observed more at tail than head. In Figure 07, chlorine content were observed increasing from head to tail in HML canal. But in non-perennial canal RC, chlorine content were low from head to tail. Whether Sulphate parameter is increasing from head to tail in HML but vice versa in RC at tail as shown in figure 08. In figure 09, pH of both canals remain unchanged and within limit. EC is increasing at tail in HML but decreasing at tail in RC non-perennial canal as shown in figure 10. SAR parameter is increasing at tail in HML but decreasing at tail in RC.

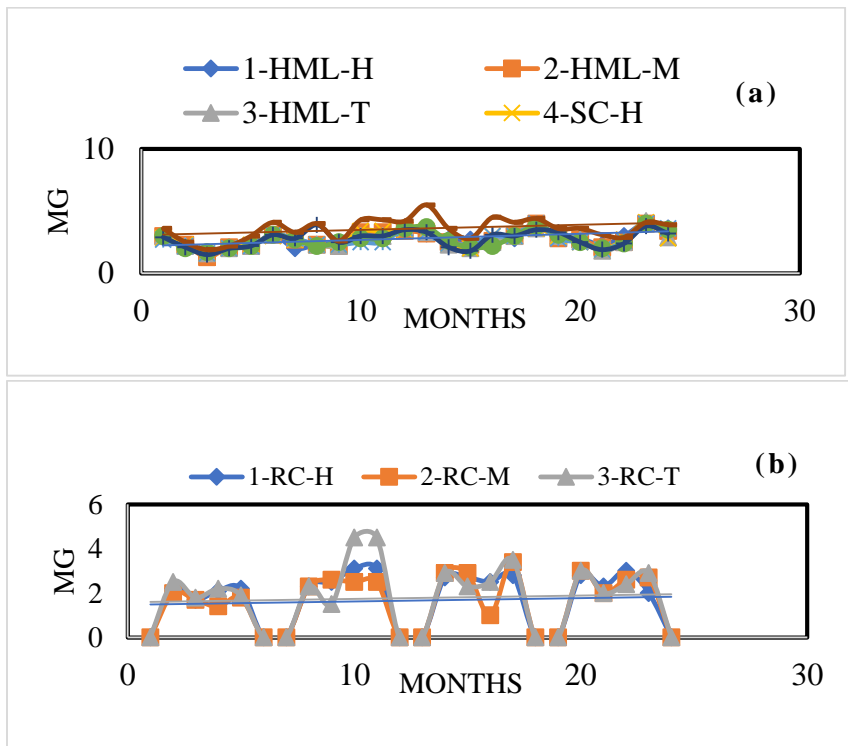


Fig. 2. Mg parameters of Surface water quality (a) HML, SC and MB canal (b) RC

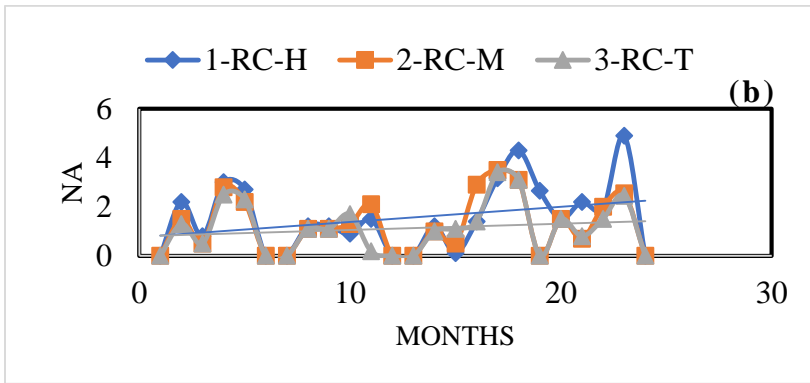
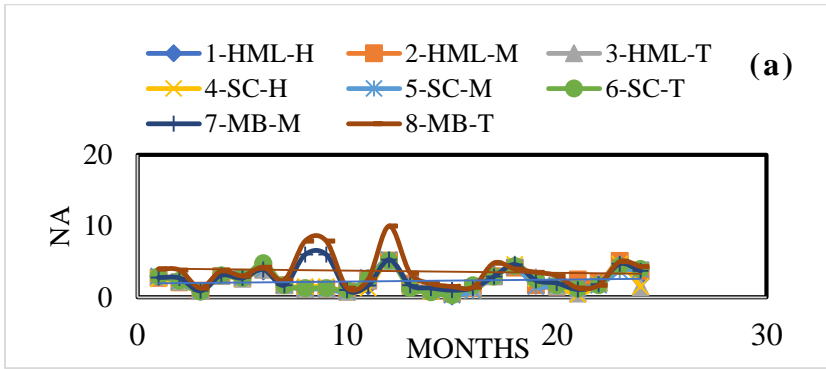
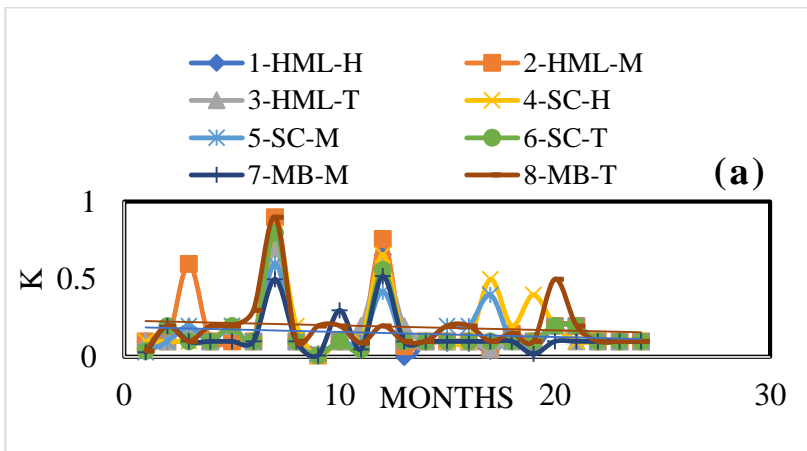


Fig. 3. Na parameter of Surface water quality (a) HML, SC and MB canal (b) RC



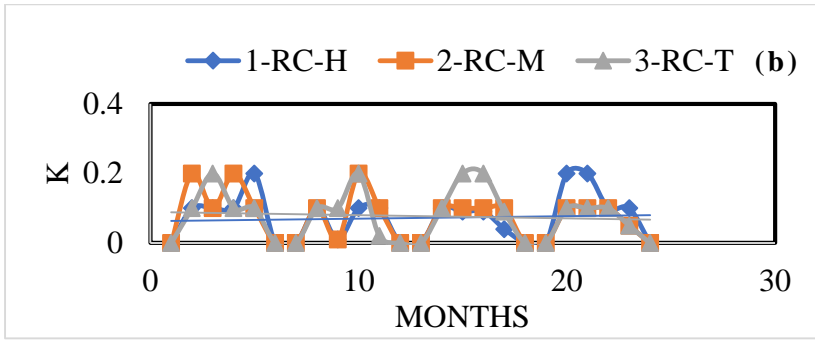


Fig. 4. K parameter of Surface water quality (a) HML, SC and MB canal (b) RC

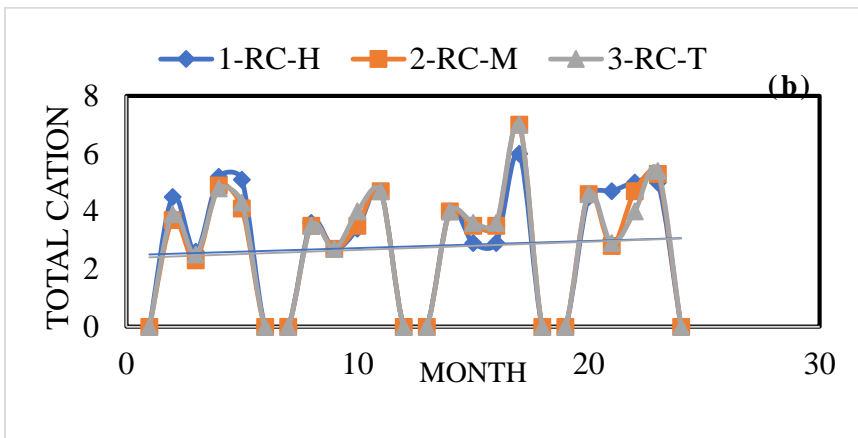
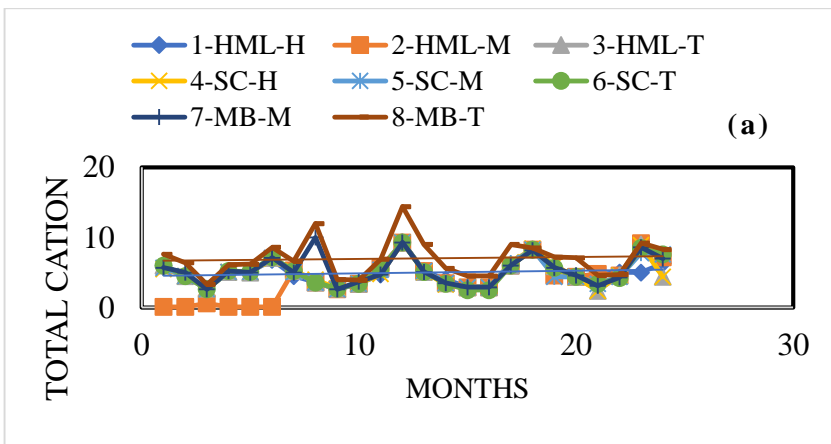


Fig. 5. Total Cation of Surface water quality (a) HML, SC and MB canal (b) RC

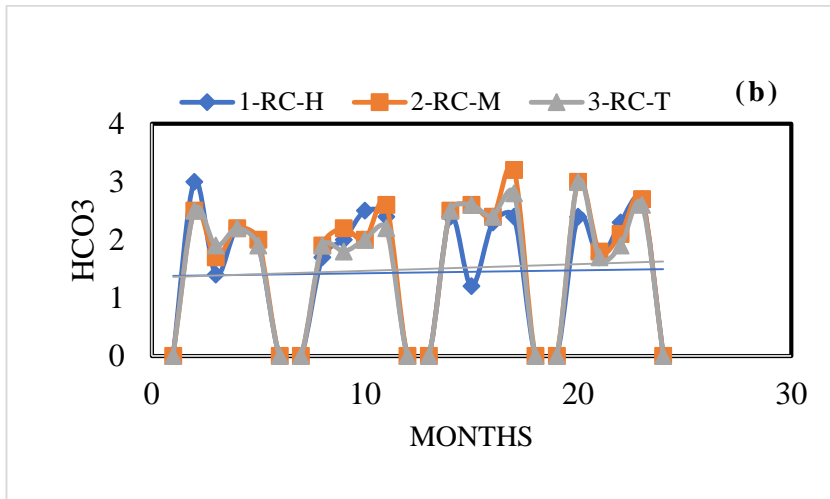
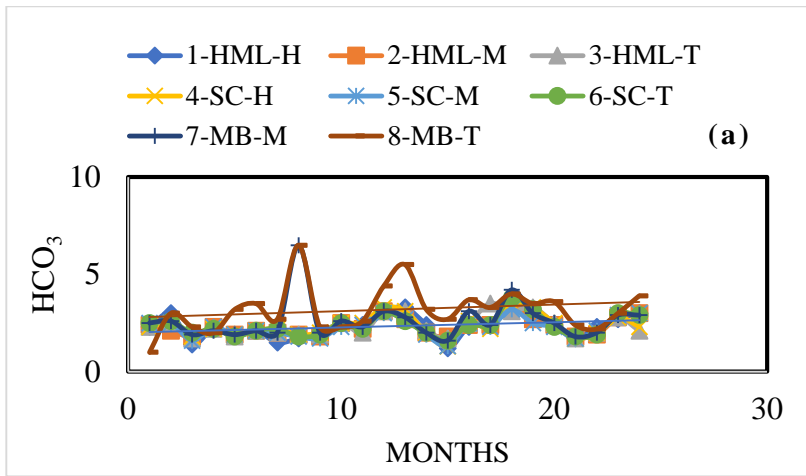
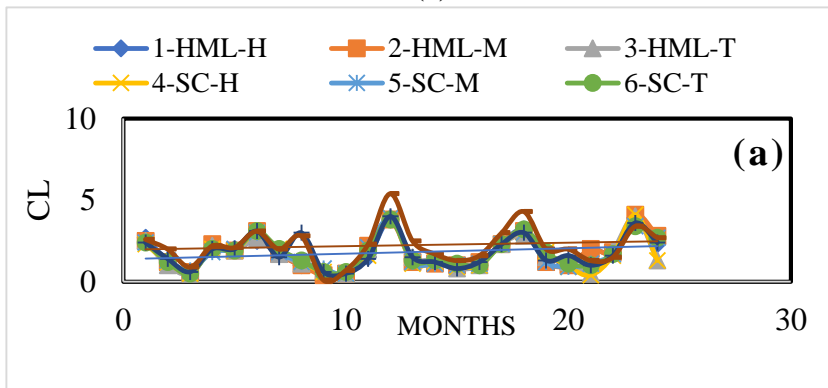


Fig. 6. HCO_3^- parameter of Surface water quality (a) HML, SC and MB canal (b) RC



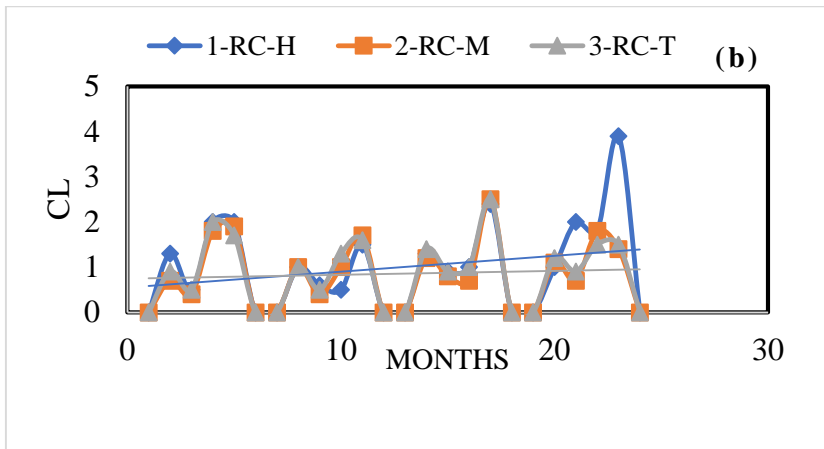


Fig. 7. CL parameter of Surface water quality (a) HML, SC and MB canal (b) RC

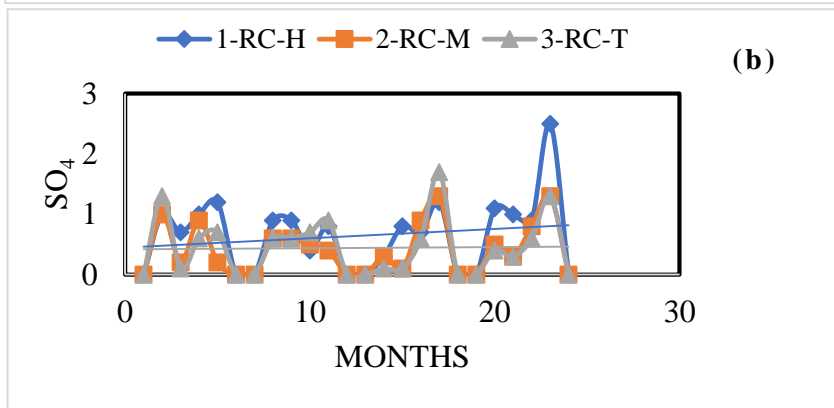
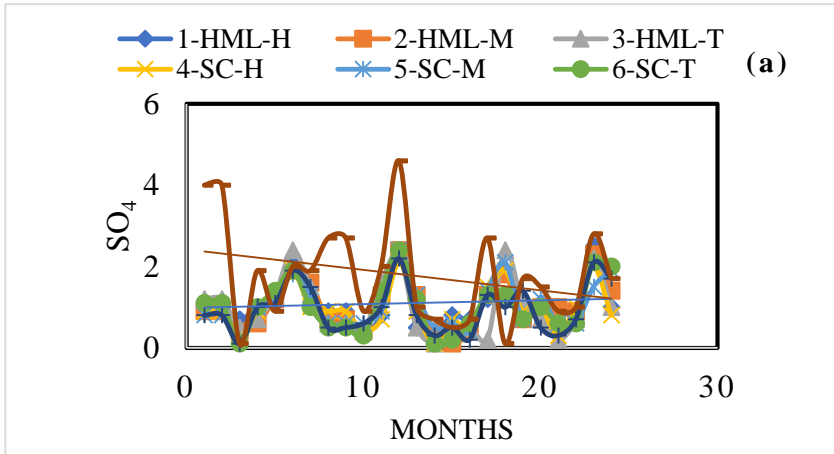


Fig. 8. SO_4 parameter of Surface water quality (a) HML, SC and MB canal (b) RC

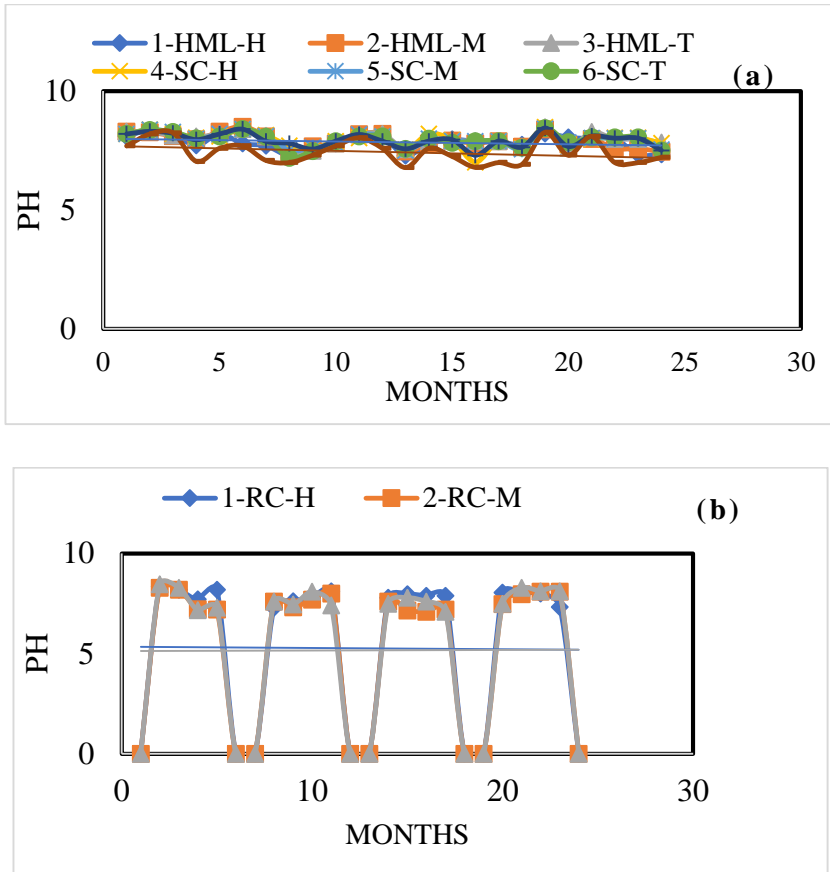
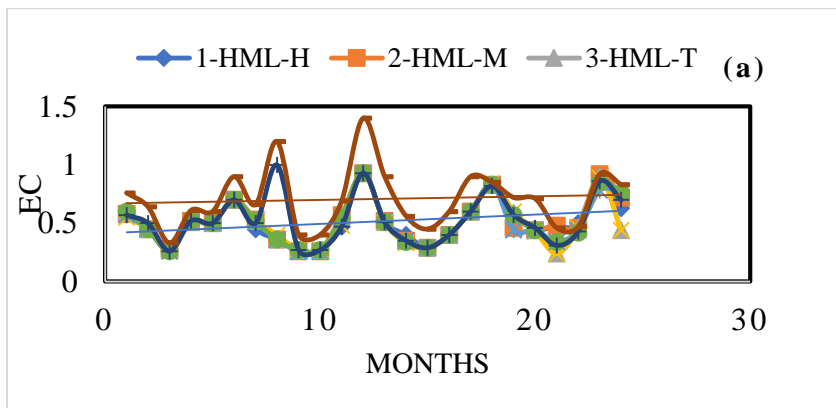


Fig. 9. PH parameter of Surface water quality (a) HML, SC and MB can



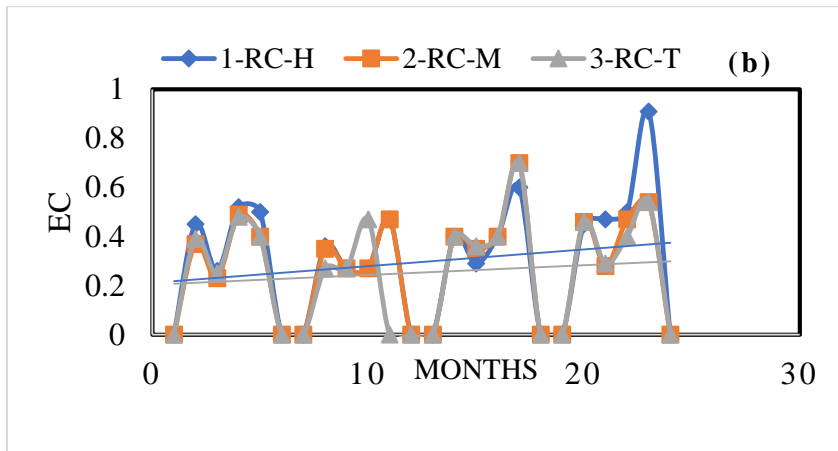


Fig. 10. EC parameter of Surface water quality (a) HML, SC and MB canal (b) RC

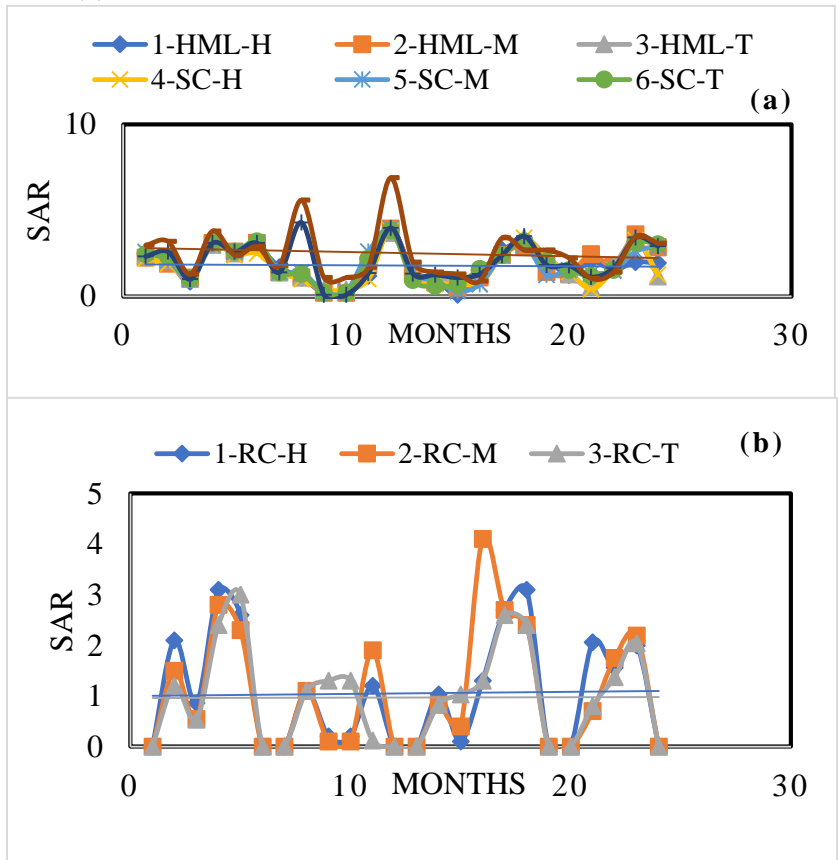


Fig. 11. SAR parameter of Surface water quality (a) HML, SC and MB canal (b) RC (non-perennial canal)

Conclusion

This research was conducted to check the difference and surface water quality of two off-taking canals, one is perennial and other is non-perennial. The trends were observed through different charts of 10 true reference monitoring sites for 4 years analysis. Mostly parameters were observed maximum at tail than head with spatio-temporal scale in HML-perennial canal. But opposite in Rangpur canal (non-perennial canal) more values were observed at head of the canal than tail. Most of the parameters of surface water quality were in limited range but increasing towards threshold limit in upcoming years due to agricultural runoff, industrial effluent and sewerage water mixing into these canals. Most threat values with increasing trend was observed at Sidhnai canal tail due to mixing of undesirable materials. This research will be helpful for the water expert's policy maker to control the surface water quality that is still within limited range but increasing year by year. Following recommendations are given as: The effluent discharge of societies, colonies, industries and agriculture whose drop it toward canal should be banned. Non perennial canals are more polluted than perennial canals because people hesitate to through effluent because it cannot be cleaned until, canal flow regularly. Therefore, most of the people dump waste at proper sites.

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