Pak. J. Bot., 50(3): 1135-1145, 2018.

CHANGES IN VEGETATION STRUCTURE AND SOIL COMPONENTS AT UPSTREAM AND DOWNSTREAM AREAS OF ALAQIQ DAM, SOUTHWESTERN SAUDI ARABIA

SAMI ASIR AL-ROBAI[1*], HAIDAR ABDALGADIR MOHAMED[1,2], ABDELAZIM ALI AHMED[1,3] AND EMAD ALI ALSHERIF[4,5]

[1]*Department of Biology, Faculty of Science, University of Albaha, Albaha, Saudi Arabia*
[2]*Medicinal and Aromatic Plants Research Institute, National Council for Research, Sudan*
[3]*Department of Botany, Faculty of Science, University of Khartoum, Sudan*
[4]*Department of Biology, Faculty of Sciences and Arts-Khulais, Jeddah University, Saudi Arabia*
[5] *Department of Botany, Faculty of Science, Beni Suef University, Egypt*
[*]*Correspondence author's: dr.alrobai@gmail.com*

Abstract

This work aimed at studying the changes in the vegetation structure and soil components at upstream and downstream areas of Alaqiq dam. A total of 169 species belonging to 124 genera and 47 families were recorded from the area. The upstream zone had 123 species, 98 genera, 41 families while downstream zone had 101 species, 81 genera, 35 families. Poaceae was the dominant family in the study area with 14 genera and 19 species. Therophytes and chamaephytes were the most common life forms indicating a typical desert life-form spectrum. TWINSPAN classified the studied sites into two main groups; the near upstream site represented the first group while the other three sites combined together in the second group. JACCARD'S similarity value revealed that there was a high similarity between far downstream and near downstream sites. Diversity values of Simpson, Shannon-Wiener and Margalef demonstrated that the two near sites of the dam were more diverse than the two far sites. The soil of the study area was not saline (0.18 – 0.86 dS/m),slightly alkaline (pH, 8.46 – 8.62), contained 307.7 – 667.8 mg kg^{-1} nitrogen and very poor in phosphorus content (< 0.001 mg kg^{-1}).The upstream area had high amount of nitrogen (667.8 mg kg^{-1}) and water (21.47%) contents as compared with the downstream area. This result suggested that the nitrogen and soil water contents strongly influenced the distribution of plants at both areas of the dam. The trace and toxic elements were found in the soil at unpolluted level.

Key words: Vegetation structure, Plant diversity and community, Soil components, Alaqiq dam.

Introduction

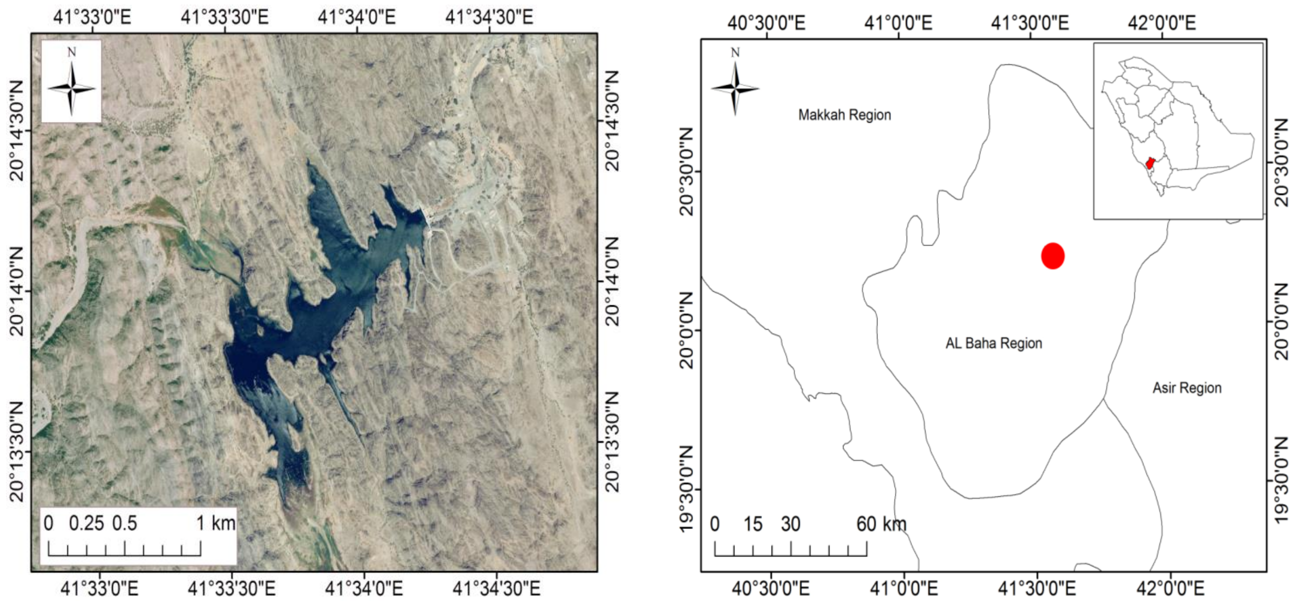
The Kingdom of Saudi Arabia lies in a harsh natural desert environment with no rivers or lakes. It is divided into two distinct zones, the rainy highlands of the western and southwestern regions and the arid and more arid zone (Al-Nafie, 2008). Albaha region, southwestern of Saudi Arabia is located in the first zone and characterized by rainfall events during the entire year due to the topographically driven convective rain (Abdullah & Al-Mazroui, 1998). In the country, the runoff water from Valleys (*Wadis*) mainly during November and April is captured in 260 dams collecting an estimated 6 billion m^3 of water per year (Al-Zahrani & Baig, 2011). During drought period, dams have played a great role in storing water (Qureshi *et al.*, 2014; Mahmoud & Alazba, 2015a). World Commission on Dams in 2005 has reported that there were more than 50 000 dams in the world and nearly 20% of the freshwater flowing to the oceans is estimated to be controlled by dams (Thomson *et al*., 2005; Merritt & Wohl, 2006).

Damming would likely reduce biodiversity and ecosystem service values of both aquatic and terrestrial ecosystems within the watersheds (Grumbine &Xu, 2011). It is also, affects shoreline vegetation and have the potential to change surrounding plant communities (Nilsson &Berggren, 2000; Qureshi *et al.,* 2014). Therefore, it is necessary to study the effects of dam construction on ecosystem structure and integrity. Other studies (Ellery *et al*., 1993; Auble *et al*., 1994; Qureshi *et al.,* 2014) revealed that the groundwater availability is the limiting factor affecting plant species, growth, establishment and survival.

Like other parts of the Kingdom, Albaha region is suffering from the depleted groundwater resources and most of the freshwater is not adequately conserved before dams construction. Twenty-five rainwater-harvesting and groundwater recharge dams have been constructed in Albaha region, southwestern, Saudi Arabia (Mahmoud &Alazba, 2015b). Alaqiq dam which is an excellent rainwater-harvesting and groundwater recharge structure in the kingdom (Mahmoud &Alazba, 2015b; Mahmoud *et al*., 2015), is one of these dams. It was constructed on Wadi Alaqiq stream in 1987 to secure people's life, controlling flooding events and to provide potable water for Albaha region (Mahmoud &Alazba, 2015c). As no scientific studies have been carried out to assess the effect of Alaqiq dam construction on the vegetation composition and diversity till yet; therefore, this work was carried out to study the changes in vegetation structure and soil properties at upstream and downstream areas of Alaqiq dam.

Materials and Methods

Study area: Alaqiq dam (41°57′E and 20.23′N), southwestern, Saudi Arabia, lies 40 km east Albaha city (Fig. 1). Morphometric analysis revealed that the maximum elevation in Al-aqiq dam upper stream is about 1600 m above sea level; stream length is about 533 km; area is about 309 km^2 and perimeter is about 119 km (Mahmoud &Alazba, 2015c). The climate is dry and semi arid belonging to tropical/subtropical desert (Ayele &Al Shadily, 2000). The recorded temperature and rainfall values in the area during Jan – Dec, 2016 were ranging from 15.9 to 29.9°C and from 0 to 124.2 mm, respectively (Fig. 2). The area is characterized by huge and steep Rocky Mountains (Alahmed *et al*., 2010). Most of the soils in the study area are sandy loam or loamy sand to clay texture and mostly blocky or massive while granular structure at surface layers (Sallam, 2002).



MAC: Maximum Allowable Concentrations of trace elements in agricultural soils proposed by Mrvic (2011).
Fig. 1. Map of Alaqiq dam and the study area.

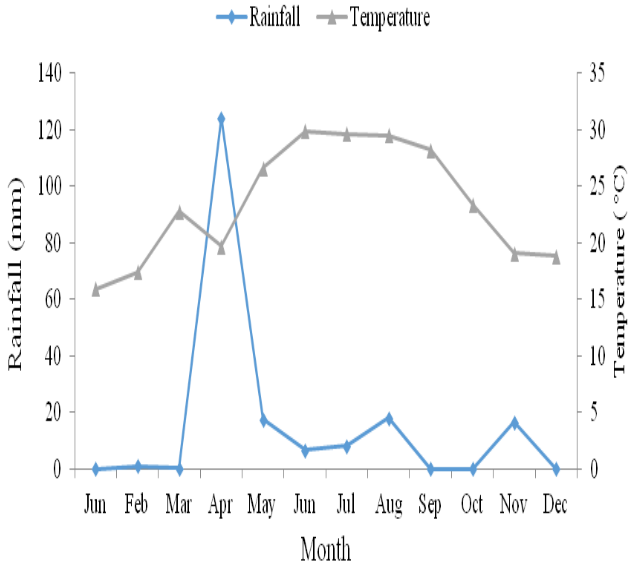


Fig. 2. Monthly variation in air temperature (°C) and precipitation (mm) as recorded at Albaha meteorological station during Jan – Dec, 2016.

Field survey: Intensive field trips were made to the study area during a course of one year from January – December, 2016. The study area was divided into two major areas, upstream (reservoir area) and downstream, each area was divided into two sites (near and far from the dam) with 20 stands. The stands werelaid perpendicular tothe stream length and in each stand 30 quadrates (10 × 10 m) were randomly selected. Plant species were collected, identified and named according to Chaudhary (1989, 1999, 2000, 2001), Chaudhary & Al Jowaid (1999) and Collenette (1999). Nomenclature and citation and Synonyms were updated from electronic sources and authenticated international data. Voucher specimens were deposited at Department of Biology, Faculty of Science, Albaha University.

Soil analysis: Three soil samples (0 - 30 cm depth) were randomly taken from each site and then mixed well to form a composite soil sample. They were air-dried to constant weight, ground and sieved to 2 mm prior to chemical analysis. Soil water extracts (1:5) were prepared for the determination of electrical conductivity (EC) and pH using a digital pH-meter (pH/ORP/Ion/Conductivity meter SG78). Walkley–Black method further modified by Yeomans & Bremner(1998) was used for determining the organic carbon content, and the total nitrogen was analyzed by Kjeldahl method (Bremner, 1996).For metal analysis, 0.25 g of a sample was digested by a microwave oven (Anton-Paar PE Multiwave 3000) with 4 mL HNO_3 (65%), 1 mL HCl (36%), 2 mL H_2O_2 (30% w/v) and 1 mL deionized H_2O (Milli-Q quality). The digested samples were analyzed with the inductively coupled plasma-optical emission spectrometry (ICP-OES, 7000 DV, Perkin Elmer, USA).

Data analysis: Life forms of the species were classified following the Raunkiaer (1937) systems with some modifications. Vegetation classification technique was employed; the stand-species data matrix was classified into groups using the importance values of species by means of the Two Way Indicator Species Analysis (TWINSPAN) computer program (Hill, 1979). The floristic similarities among different sites were assessed by performing a hierarchical classification analysis based on presence/absence data with Ward's minimum variance method and Euclidean distances as a dissimilarity measure (Ward, 1963). Jaccard's similarity index was applied to evaluate ß-diversity/similarity among stands, which is based on presence/absence of species (Castro &Jaksic, 2008). The PAST (*Paleontological Statistics*) program version 3.14 which generates some diversity indices (Table 1) was used to analyze the recorded data (Hammer *et al*., 2001).

Table 1. Formula of diversity indices used for analyzing the collected data.

Index	Formula	Formula description	Reference
Shannon-Wiener (H')	$H' = -\sum_{i=0}^{s}\left(\frac{ni}{N}\right)\ln\left(\frac{ni}{N}\right)$	ni = number of individuals of each species. N = total number of individuals in all sites. ln = the natural log of the number	Shannon &Weiner (1963)
Simpson (D)	$D = 1 - \sum\frac{ni(ni-1)}{N(N-1)}$	ni = number of individuals of each species. N = total number of individuals in all sites	Simpson (1949)
Margalf (M)	$M = \frac{(S-1)}{\ln N}$	S= the number of species in the sample. N =total number of individuals in the sample ln = the natural log of the number.	Margalef (1958)

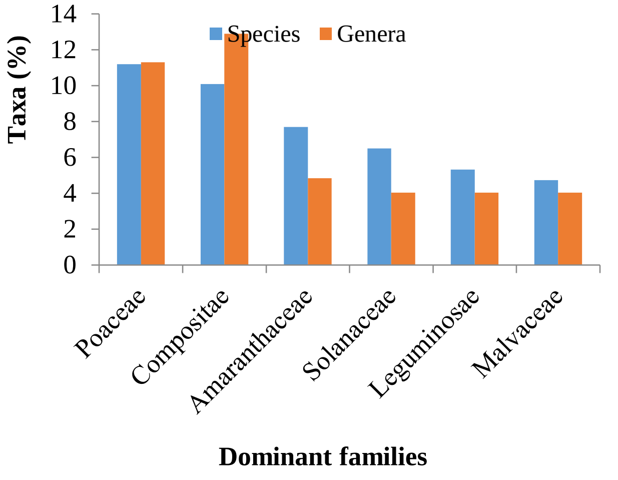


Fig. 3. Percentage of species and genera in the dominant families from the study area.

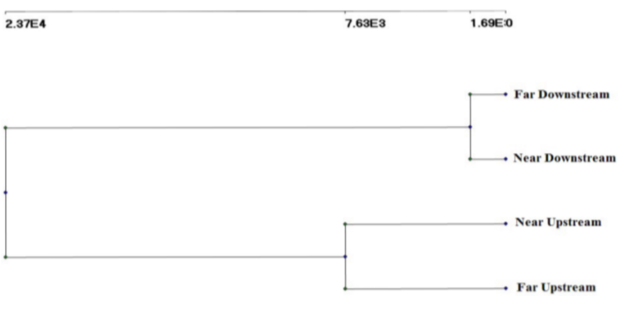


Fig. 4. The dendrogram obtained from the hierarchical classification showing plant community types of the study area.

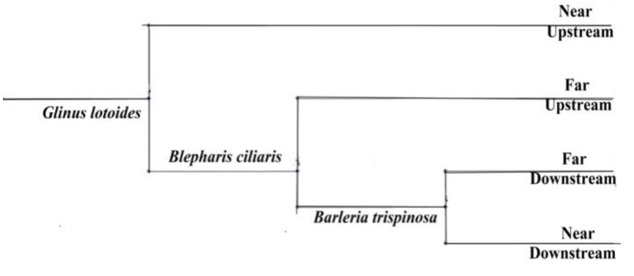


Fig. 5. Vegetation clusters resulting from the TWINSPAN classification.

Results and Discussion

Floristic composition and life forms spectra: Table 2 presents the floristic composition and life forms spectra of the downstream and upstream areas. The total recorded taxa in the area were 169 species, 124 genera and 47 families. The high number of taxa (113 species, 91 genera and 41 families) was recorded in the near upstream site followed by the near downstream site (94 species, 75 genera and 33 families), far upstream site (80 species, 64 genera and 28 families) and far downstream site (69 species, 59 genera and 29 families). Poaceae (11.2% species, 11.3% genera) and Compositae (10.1% species, 12.9% genera) were the most dominant families followed by Amaranthaceae, Solanaceae, Leguminosae and Malvaceae (Fig. 3). Several authors (Osman *et al.*, 2014; Alsherif &Fadl, 2016; Al-Robai *et al*., 2017) stated that compositae and poaceae were the most dominant families in Saudi Arabia. However, Poaceae is the largest and most widespread family of flowering plants in the world (Good, 1974; Qureshi, 2012; Ilyas *et al.*, 2013a,b; Khan *et al.*, 2015). The wide spread of this family all over the world may be due to its wide ecological range of tolerance and its efficient seed dispersal ability (Qureshi, 2012: Alsherif *et al*., 2013).

According to the life forms classification of Raunkiaer (1937), nine categories were recorded in the area. The most frequent plant life form in upstream area was therophytes (39%) followed by chamaephytes (32.5%). In contrast, the downstream area was dominated by chamaephytes (38.61%) followed by therophytes (34.65%) (Table 3). The obtained results were in agreement with other previous studies at different regions of Saudi Arabia (Al sheriff *et al*., 2013; Abdel Khalik*et al*., 2013; Alsherif &Fadl, 2016; Al-Robai *et al.*, 2017). El-Demerdash *et al.*, (1994), Heneidy & Bidak (2001) and Ilyas *et al*., (2013b) attribute the dominance of therophytes and chamaephytes to hot dry climate, topography variations and biotic influence. Three species (*Cyperus rotundus*, *Cynodon dactylon*and *Hyparrhenia hirta*) were geophytes and parasitic plants were represented by two species (*Cuscuta campestris* and*Viscumschimperi*). Epiphytes were represented by three species (*Ephedra alata*, *Ephedraaphylla* and *Phragmanthera austroarabica*).

Plant community analysis: The dendrogram obtained from the hierarchical classification differentiated the studied sites into two primary groups (Fig. 4). The first group included two subgroups, far downstream and near downstream sites. The second main group was upstream site, which was divided into two subgroups, far upstream and near upstream sites. TWINSPAN separated the four sites into two main groups (Fig. 5), with *Glinus lotoides* as indicator species. Group A contained near upstream site and group B included the other three sites, which was subdivided into two subgroups, one included far downstream site and near downstream sites while the other contained far upstream site. Pervious study showed that dam construction changes the coverage of plant communities, plant species richness and destroys the connectivity between upstream and downstream of the dam (Sun *et al.*, 2014; Qureshi *et al.*, 2014).

Table 2. Floristic composition and life form spectra of the downstream and upstream areas of the dam.

Botanical name	Life form	Downstream		Upstream	
		Far site	Near site	Near site	Far site
Acanthaceae					
Barleria bispinosa (Forssk.) Vahl	CH	+	−	−	−
Barleria trispinosa (Forssk.) Vahl	CH	−	−	−	+
Blepharis ciliaris (L.) B.L.Burtt	HE	+	+	+	+
Justicia flava (Forssk.) Vahl	TH	−	−	−	+
Aizoaceae					
Aizoon canariense L.	TH	+	+	+	+
Zaleya pentandra (L.) C. Jeffrey	HE	+	+	+	+
Amaranthaceae					
Aerva javanica (Burm.f.) Juss. ex Schult.	CH	+	+	+	+
Aerva lanata (L.) Juss.	CH	−	−	+	+
Amaranthus graecizans L.	TH	+	+	+	−
Amaranthus blitum subsp. *oleraceus* (L.) Costea	TH	−	+	−	−
Amaranthus viridis L.	TH	+	+	−	−
Chenopodium album L.	TH	−	−	+	+
Chenopodium carinatum R.Br.	TH	−	−	+	+
*Chenopodiummurale*L.	TH	−	−	+	+
Dysphania schraderiana (Schult.) Mosyakin & Clemants	TH	−	+	+	−
Pupalia lappacea (L.) Juss.	CH	+	+	−	−
Salsola imbricata Forssk.	CH	+	+	+	+
Salsola kali L.	CH	+	+	+	+
Salsola spinescens Moq.	CH	−	+	−	−
Anacardiaceae					
Pistacia khinjuk Stocks	PH	−	−	+	−
Apiaceae					
Torilisar vensis (Huds.) Link	TH	−	−	+	−
Apocynaceae					
Calotropis procera (Aiton) Dryand.	PH	+	+	+	+
Caralluma quadrangular (Forssk.) N.E.Br.	CH	−	−	+	−
Caralluma retrospiciens (Ehrenb.) N.E.Br	CH	−	+	+	−
Leptadenia sp	TH	−	+	−	−
Odontanthera radians (Forssk.) D.V.Field	TH	−	+	−	−
Pergularia tomentosa L.	CH	+	+	−	−
Periploca aphylla Decne.	PH	−	−	+	+
Boraginaceae					
Heliotropium longiflorum (A.DC.) Jaub. & Spach	CH	−	−	+	−
Trichodesma africanum (L.) Sm.	TH	−	−	+	+
Brassicaceae					
Diplotaxis harra (Forssk.) Boiss.	CH	−	+	+	−
Farsetia longisiliqua Decne.	CH	+	+	+	+
Morettia parviflora Boiss.	CH	+	+	+	+
Sisymbrium erysimoides Desf.	TH	−	−	+	+
Notoceras bicorne (Aiton) Amo	TH	+	+	−	−
Capparaceae					
Capparis deciduas (Forssk.) Edgew.	PH	+	+	−	−
Capparis cartilaginea Decne.	CH	−	+	+	+
Maerua crassifolia Forssk.	PH	+	−	−	+
Caryophyllaceae					
Cometes abyssinica R.Br. ex Wall.	TH	+	−	−	−
Cometes surattensis Burm.f.	TH	−	−	+	−
Minuartia filifolia Mattf.	TH	−	−	+	−
Polycarpon tetraphyllum L.	TH	−	−	+	−
Celastraceae					
Maytenus parviflora (Vahl) Sebsebe	PH	−	+	−	−

Table 2. (Cont'd.).

Botanical name	Life form	Downstream		Upstream	
		Far site	Near site	Near site	Far site
Cleomaceae					
Cleome ramosissina Parl. ex Webb	CH	−	−	+	+
Compositae					
Ambrosia maritime L.	CH	−	−	+	+
Calendula arvensis M.Bieb.	TH	+	−	−	−
Conyza pyrrhopappa Sch. Bip. ex A.Rich.	TH	−	−	+	−
Echinops spinosissimus Turra	HE	−	−	+	+
Eclipta prostrate L.	TH	−	+	−	−
Erigeron bonariensis L.	CH	−	−	+	+
Filago desertorum Pomel	TH	−	+	−	−
Flaveria trinervia (Spreng.) C.Mohr	TH	+	+	+	+
Helichrysum glumaceum DC.	TH	−	−	+	+
Kleinia odora (Forssk.) DC.	CH	−	−	+	−
Pluchea dioscoridis (L.) DC.	CH	−	−	+	+
Pulicaria crispa Sch.Bip.	CH	+	+	+	+
Pulicaria schimperi DC.	TH	+	−	−	+
Senecio flavus (Decne.) Sch.Bip.	TH	−	−	+	+
Sonchus tenerrimus L.	TH	+	+	+	−
Tripteris vaillantii Decne.	CH	+	+	−	−
Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray	TH	−	−	+	+
Convolvulaceae					
Cuscuta campestris Yunck.	PR	−	+	−	−
Cucurbitaceae					
Citrullus colocynthis (L.) Schrad.	HE	+	+	−	−
Cucumis prophetarum L.	HE	−	−	+	−
Coccinia grandis (L.) Voigt	HE	−	−	+	+
Kedrostis gijef C. Jeffrey	HE	−	+	−	−
Cyperaceae					
Cyperus rotundus L.	GE	+	+	+	+
Ephedraceae					
Ephedra alata Decne.	EP	−	−	+	−
Ephedra aphylla Forssk.	EP	+	+	−	−
Ephedra sp.	CH	−	−	+	−
Euphorbiaceae					
Chrozophora oblongifolia (Delile) A. Juss. ex Spreng.	CH	+	+	−	−
Chrozophora tinctoria (L.) A.Juss.	CH	+	+	−	−
Euphorbia punctulata Andersson	TH	+	+	−	−
Euphorbia granulate Forssk.	TH	+	+	+	+
Ricinus communis L.	PH	+	+	+	+
Geraniaceae					
Erodium glaucophyllum (L.) L'Hér.	HE	−	+	−	−
Erodium neuradifolium Delile ex Godr.	TH	−	−	+	−
Gisekiaceae					
Gisekia pharnaceoides L.	TH	−	−	+	−
Juncaceae					
Juncus punctorius L.f.	HL	−	+	+	−
Lamiaceae					
*Ajugacham aepitys*sub sp. *Tridactylites* (Ging. ex Benth.) P.H. Davis	HE	−	−	−	+
Lavandula dentate L.	CH	+	+	+	+
Mentha longifolia (L.) L.	CH	−	−	+	+
Otostegia fruticosa (Forssk.) Schweinf. ex Penzig	CH	−	+	+	−
Salvia aegyptiaca L.	CH	−	+	−	+
Leguminosae					
Acacia asak (Forssk.) Willd.	PH	+	+	+	+
Acacia ehrenbergiana Hayne	PH	+	+	+	+

Table 2. (Cont'd.).

Botanical name	Life form	Downstream		Upstream	
		Far site	Near site	Near site	Far site
Acacia etbaica Schweinf.	PH	−	−	+	+
Acacia tortilis sub sp. *Raddiana* (Savi) Brenan	PH	−	−	−	+
Astragalus eremophilus Boiss.	TH	−	−	−	+
Astragalus sieberi DC.	CH	−	+	−	−
Crotalariaemarginella Vatke	CH	−	−	+	+
Indigofera spinosa Forssk.	CH	+	+	+	−
Medicago lupulina L.	HE	−	+	+	−
Loranthaceae					
Phragmanthera austroarabica A.G. Miller & J. Nyberg	EP	+	−	−	−
Malvaceae					
Abutilon bidentatum Hochst. ex A. Rich.	CH	+	+	−	−
Abutilon pannosum (G.Forst.) Schltdl.	CH	+	+	−	−
Grewia tembensis Fresen.	PH	−	−	+	−
Grewia sp.	PH	+	−	+	−
Hibiscus deflersii Schweinf. ex Cufod.	TH	−	−	+	+
Hibiscus micranthus L.f.	CH	+	+	−	+
Malva parviflora L.	TH	+	+	−	−
Pavonia Arabica Hochst. ex Steud.	CH	−	+	−	−
Menispermaceae					
Cocculus pendulus (J.R. Forst. & G. Forst.) Diels	CH	−	−	+	+
Molluginaceae					
Glinus lotoides L.	TH	+	+	+	+
Mollugo cerviana (L.) Ser.	TH	−	+	−	−
Moraceae					
Ficus cordata subsp. *Salicifolia* (Vahl) C.C. Berg	PH	−	−	+	−
Ficus palmate Forssk.	PH	+	+	−	−
Nyctaginaceae					
Boerhavia coccinea Mill.	CH	−	−	+	−
Boerhavia repens L.	CH	−	+	−	−
Boerhavia boissieri Heimerl	CH	−	−	+	+
Boerhavia helenae Roem. & Schult.	CH	+	+	+	+
Boerhavia sinuate (Meikle) Greuter & Burdet	CH	−	+	+	−
Papaveraceae					
Argemone ochroleuca Sweet	TH	+	+	+	+
Phyllanthaceae					
Andrachne aspera Spreng.	CH	−	+	+	−
Phyllanthus maderaspatensis L.	TH	−	−	+	−
Plantaginaceae					
Kickxia hastate (R.Br. ex Benth.) Dandy	TH	+	+	+	−
Kickxia pseudoscoparia V.W. Sm. & D.A. Sutton	TH	−	−	+	+
Linaria chalepensis (L.) Mill.	TH	−	−	+	−
*Plantagoovata*Forssk.	HE	−	−	+	−
Veronica anagallis−aquatica L.	HY	−	−	+	−
Plumbaginaceae					
Limonium lobatum (L.f.) Kuntze	TH	−	−	+	−
Poaceae					
Aristida adscensionis L.	TH	+	+	+	+
Aristida purpurea Nutt.	TH	+	+	+	+
Brachiaria reptans (L.) C.A. Gardner & C.E. Hubb.	TH	+	+	+	+
Cenchrus ciliaris L.	HE	−	−	+	+
Cynodon dactylon (L.) Pers.	GE	+	+	+	+
Dactyloctenium aegyptium (L.) Willd.	TH	−	−	+	−
Dactyloctenium aristatum Link	TH	−	−	+	+
Digitaria ciliaris (Retz.) Koeler	TH	+	+	−	−
Digitaria pennata (Hochst.) T. Cooke	HE	−	−	+	+

Table 2. (Cont'd.).

Botanical name	Life form	Downstream		Upstream	
		Far site	Near site	Near site	Far site
Digitaria sanguinalis (L.) Scop.	TH	+	+	−	−
Eragrostis aspera (Jacq.) Nees	TH	+	+	+	+
Eragrostis minor Host	TH	−	−	+	+
Hyparrhenia hirta (L.) Stapf	GE	−	−	+	+
Panicumantidotale Retz.	HE	−	−	−	+
Poa annua L.	TH	+	+	−	−
Rostrariacristata (L.) Tzvelev	HE	−	−	+	−
Stipa tigrensis Chiov.	TH	−	−	+	+
Stipagrostis plumose Munro ex T. Anderson	TH	−	+	−	−
Tetrapogon villosus Desf.	TH	−	−	+	−
Polygalaceae					
Polygala abyssinica R.Br. ex Fresen.	HE	−	+	+	+
Polygonaceae					
Rumex pictus Forssk.	HE	+	+	−	−
Rumexsteudelii Hochst. ex A. Rich.	TH	−	+	−	−
Rumex vesicarius L.	HE	−	+	−	−
Portulacaceae					
Portulaca oleracea L.	TH	+	+	−	−
Primulaceae					
Anagallisarvensis L.	TH	−	−	+	+
Resedaceae					
Ochradenus baccatus Delile	CH	+	+	+	+
Rhaminaceae					
Ziziphus spina−christi (L.) Desf.	PH	+	+	+	+
Rubiaceae					
Galium aparine L.	TH	−	−	+	−
Santalaceae					
Viscum schimperi Engl.	PR	−	+	−	−
Sapindaceae					
Dodonaea viscosa subsp. *Angustifolia* (L.f.) J.G. West	CH	−	−	+	−
Scrophulariaceae					
Anticharisarabica Endl.	TH	−	−	+	−
Solanaceae					
*Daturainnoxia*Mill.	TH	+	+	+	+
Datura stramonium L.	TH	−	−	+	+
Lycium depressum Stocks	PH	−	−	+	+
Lycium shawii Roem. & Schult.	PH	+	+	+	+
Nicotiana glauca Graham	PH	+	+	+	+
Solanum sp.	CH	−	+	−	−
Solanum americanum Mill.	CH	−	+	−	−
Solanum coagulans Forssk.	CH	−	−	+	−
Solanum incanum L.	CH	+	+	+	+
Solanum villosum Mill.	TH	+	+	+	−
Withania somnifera (L.) Dunal	CH	+	+	−	−
Urticaceae					
Forsskaolea tenacissima L.	CH	+	+	+	+
Zygophyllaceae					
Fagonia arabica L.	CH	−	+	+	+
Fagonia bruguieri DC.	CH	+	+	+	+
Fagonia cretica L.	CH	−	−	+	+
Tetraenasimplex (L.) Beier & Thulin	CH	+	+	−	−
Tribulus terrestris L.	TH	+	+	+	+

(TH = Therophytes, HY = Hydrophytes, HL = Helophytes, HE = Hemicryptophytes, GE = Geophytes, CH = Chamaephytes, PH = Phanerophytes, PR = Parasites, EP = Epiphytes).

Table 3. Percentage (%) of families, genera, species, individual and life forms spectra in the different sites of the study area.

	Downstream area		Upstream area	
	Far site	Near site	Near site	Far site
Families	62.22	68.89	86.67	60
Genera	47.59	60.48	73.39	51.61
Species	41.18	55.88	66.47	47.06
Individual	16.06	17.46	40.06	26.42
CH	34.78	39.36	32.74	33.75
TH	37.68	34.04	39.82	36.25
PH	15.94	10.64	12.39	15
HE	5.80	9.57	9.73	11.25
GE	2.90	2.13	2.65	3.75
PR	0	2.13	0	0
HL	0	1.06	0.88	0
EP	2.90	1.06	0.88	0
HY	0	0	0.88	0

Plant diversity analysis: Jaccard's similarity value indicated that the far downstream and near downstream sites shared high similarity, followed by far upstream and down upstream sites while near upstream and far downstream sites showed less similarity (Table 4). The lowest similarity value between near upstream and far downstream could be attributed to variation in salinity as well as moisture and nitrogen contents between the two sites.

As shown from Table 5, the values of Simpson (0.9551) and Shannon-Wiener (3.741) were relatively high in near downstream site followed by near upstream site (0.9335 for Simpson and 3.322 for Shannon-Wiener). In contrast, the highest Margalef value was recorded in near upstream (16.57) site followed by near downstream site (15.85). The calculated diversity indices indicated a clear variation in plant species diversity among the studied four sites. The downstream site was less diverse in species composition and richness; this may be due to the impact of dam construction.

As a result of dam construction, the new formed soil nutrient conditions could help one or more plant species to colonize or invade the habitat (Asaeda *et al*., 2011). It was observed that *Nicotiana glauca* and *Argemone ochroleuca* were widely spread in the study area. The wide spreading of these two species may be due to dam construction. Li *et al.,* (2012) confirmed that dam construction can facilitate the invasion of exotic species. Other studies (Stave *et al*., 2005; Tealdi *et al*., 2011; Qureshi *et al*., 2014) found that damming remarkably impacts habitat heterogeneity, declines species richness and native species and exotic species invasion. Dixon & Turner (2006) and Graf (2006) demonstrated that the effects of dams induce changes in downstream hydrology, geomorphology, biology and connectivity. In general, the construction of the dam influences the establishment of different habitats in upstream and downstream regions (shallow pool andreservoir habitat in upstream and arid and semi-arid habitatin downstream of a dam). On the other hand, water depth, sediment deposition and remarkably nutrient impact the characteristics of plantcommunity and environmental factors at upstream anddownstream of the dam (Merritt &Wohl, 2006).

Table 4. Jaccard's similarities between different sites.

	Far downstream site	Near downstream site	Near upstream site	Far upstream site
Far downstream site	1			
Near downstream site	0.6176	1		
Near upstream site	0.2867	0.3228	1	
Far upstream site	0.3363	0.2941	0.5726	1

Table 5. Simpson, Shannon-Wiener and Margalef diversity indices as calculated by PAST software package.

Index	Downstream area		Upstream area	
	Far site	Near site	Near site	Far site
Simpson (D)	0.9083	0.9551	0.9335	0.9283
Shannon-Wiener (H')	3.134	3.741	3.322	3.202
Margalef (M)	11.8	15.85	16.57	12.45

Soil properties: Table 6 summarizes the moisture, pH, electrical conductivity and element contents of the collected soil samples from the study area.Edaphic characteristics are among the strongest factors in determining the type of plant life(Ilyas *et al*., 2015; 2018). The near upstream site had comparatively higher amount of soil water (21.47 ± 1.8%) and nitrogen (667.8 mg kg^{-1}) contents as compared with the other three sites. The high species diversity of this site could be attributed to these factors. James *et al.,* (2005) and Schaeffer & Evans (2005) have reported that N is often considered the next most limiting resource in arid and semi-arid ecosystems after water. Competition for N by plants is thought to be generally greater than for other macronutrients (Krueger-Mangold *et al*., 2006). The phosphorus content was very poor in all soil samples. Asaeda *et al.,* (2011) demonstrated that the accumulation of sediment on either side of the dam would likely to change or alter the nutrient of this site, especially that of N and P.

The electrical conductivity of all soil samples was in the range of 0.18 to 0.86 dS/m indicating slight to moderate salt content. The salinity of far downstream site was markedly high as compared with the other three sites. The soil of the study area fall under low to medium content category of organic matter content (70-680 mg

kg^{-1}). The pH of all soil suspensions varied from 8.46-8.62 which indicating the slight alkalinity of the soil. The two sites near the dam contained high organic matter when compared with the other two sites far from the dam. The two far sites from the dam had nearly equal amount of nitrogen content. The obtained results demonstrated that the construction of the dam markedly affected the vegetation structure and the soil properties.

As shown from Table 7, the average concentrations of Pb, Zn, Cu, Cd, Ni and Cr in the soil of the study area were all extremely lower than Maximum Allowable Concentrations (MAC) of trace elements in agricultural soils proposed by Mrvic (2011). This result indicated that the soil was uncontaminated with the heavy metals. However, some heavy metals in the soil such as Cu, Fe, Mn and Zn are essential for plant growth and other are toxic such as Pb, Cd and As which could have potential risk for human health and soil quality at concentrations exceeding the permissible level.

Table 6. Moisture, pH, electrical conductivity and element (mg kg^{-1}) contents of the collected soil samples from the study area.

Parameter	Downstream area		Upstream area	
	Far site	Near site	Near site	Far site
Moisture (%)	4.24 ± 0.42	5.71 ± 0.62	21.47 ± 1.8	6.81 ± 0.82
pH	8.51 ± 0.05	8.46 ± 0.03	8.55 ± 0.05	8.62 ± 0.02
EC_{25} (dS/m)	0.8550 ± 0.09	0.1802 ± 0.01	0.4046 ± 0.05	0.1941± 0.02
C	90 ± 2.15	650 ± 11.43	680 ± 9.67	70 ± 2.17
N	386.1 ± 7.66	307.7 ± 6.89	667.8 ± 10.67	387.2 ± 5.34
P	< 0.001	< 0.001	< 0.001	< 0.001
S	0.99 ± 00	1.11 ± 0.01	1.33 ± 0.01	1.53 ± 0.03
K	82.64 ± 0.54	72.99 ± 1.42	77.91 ± 1	64.14 ± 0.78
Ca	146.90 ± 2.02	191.81 ± 0.93	185.62 ± 3.94	214.93 ± 2.36
Mg	175.65 ± 1.27	125.53 ±1.78	66.15 ± 0.41	55.41 ± 0.41
Na	86.57 ± 0.28	97.87 ± 0.51	110.03 ± 1.5	91.99 ± 1.33
Al	472.84 ± 2.28	494.00 ± 4.39	301.82 ± 7.62	240.73 ± 5.8

Table 7. Trace element contents (mg kg^{-1}) in the soil of the study area.

Traceelements	Downstream area		Upstream area		MAC
	Far site	Near site	Near site	Far site	
Fe	362.94 ± 0.08	362.17 ± 2.83	283.75 ± 4.09	260.2 ± 27.88	-
Mn	0.96 ± 0.01	0.88 ± 00	0.71 ± 0.01	0.82 ± 0.02	-
Cu	0.05	0.05	0.04	0.05	100
Ni	0.09	0.03	0.03	0.04	100
Zn	< 0.001	< 0.001	< 0.001	< 0.001	300
Mo	< 0.001	< 0.001	< 0.001	< 0.001	-
Co	0.02	0.02	0.02	0.02	-
Cr	0.20	0.11	0.08	0.11	100
Pb	< 0.001	< 0.001	< 0.001	< 0.001	100
Cd	< 0.001	< 0.001	< 0.001	< 0.001	3
As	< 0.001	< 0.001	< 0.001	< 0.001	-

Conclusion

This study was the first comprehensive attempt to establish a baseline data on the effects of Alaqiq dam construction on the vegetation structure and distribution of plant communities at the upstream and downstream areas of the dam. The obtained results showed that the dam had influenced the soil components and plant communities, sothat the species composition, richness and diversity belowthe dam were different from that of the upstream above the reservoir. These findings could provide basic information on how dams alter soil components, vegetation structure, plant communities and change the native and exotic plant species diversity in the dammed site.

References

Abdel Khalik, K., M. El-Sheikh and A. El-Aidarous. 2013. Floristic diversity and vegetation analysis of Wadi Al-Noman, Mecca, Saudi Arabia. *Turk. J. Bot.*, 37: 894-907.

Abdullah, M.A. and M.A. Al-Mazroui. 1998. Climatological study of the southwestern region of Saudi Arabia. I. Rainfall analysis. *Clim. Res.*, 9: 213-223.

Alahmed, A.M., S.M. Kheir and M.A. Al-Khereiji. 2010. Distribution of culicoides latreille (Diptera: Ceratopogonidae) in Saudi Arabia. *J. Entomol.*, 7: 227-234.

Al-Nafie, A.H. 2008. Phytogeography of Saudi Arabia. *Saudi J. Biol. Sci.*, 15: 159-176.

Al-Robai, S.A., H.A. Mohamed, S.M. Howladar and A.A. Ahmed. 2017. Vegetation structure and species diversity of

Wadi Turbah Zahran, Albaha area, southwestern Saudi Arabia. *Ann. Agric. Sci.*, 62: 61-69.

Alsherif, E.A. and M.A. Fadl. 2016. Floristic study of the Al-Shafa Highlands in Taif, Western Saudi Arabia. *Flora,* 225: 20-29.

Al-Sherif, E.A., A.M. Ayesh and S.M. Rawi. 2013. Floristic composition, life form and chorology of plant life at Khulais region, Western Saudi Arabia. *Pak. J. Bot.,* 45: 29-38.

Al-Zahrani, K.H. and M.B. Baig. 2011. Water in the Kingdom of Saudi Arabia: sustainable management options. *J Anim. Plant Sci.,* 21: 601-604.

Asaeda, T., M.H. Rashid, S. Kotagiri and T. Uchida. 2011. The role of soil characteristics in the succession of two herbaceous lianas in a modified river floodplain. *River Res. Appl.,* 27: 591-601.

Auble, G.T., J.M. Friedman and M.L. Scott. 1994. Relating riparian vegetation to present and future stream flows. *Ecol. Appl.,* 4: 544-554.

Ayele, T. and S.A. Al Shadily. 2000. Some of the engineering geological and hydrogeological problems and conditions of Ethiopia and Yemen. *Acta Geol. Univ. Comenianae.,* 55: 51-62.

Bremner, J.M. 1996. Total nitrogen. In: (Eds.): Sparks, D.L. Methods of soil analysis: Chemical methods. *Soil Sci. Soc. Am., Madison,* WI, pp. 1085-1086.

Castro, S.A. and F. Jaksic. 2008. Patterns of turnover and floristic similarity show a non-random distribution of naturalized flora in Chile, South America. *Rev. Chil. Hist. Nat.,* 81: 111-121.

Chaudhary, S.A. 1989. *Grasses of Saudi Arabia*. National Herbarium, National Agriculture and Water Research Center, Ministry of Agriculture and Water, Riyadh, Saudi Arabia.

Chaudhary, S.A. 1999. *Flora of the Kingdom of Saudi Arabia*. (vol. 1) Ministry of Agriculture and Water, Riyadh, Saudi Arabia.

Chaudhary, S.A. 2000. *Flora of the Kingdom of Saudi Arabia*. (Vol. 2, 1-3) Ministry of Agriculture and Water, Riyadh, Saudi Arabia.

Chaudhary, S.A. 2001. *Flora of the Kingdom of Saudi Arabia*. (Vol. 3) Ministry of Agriculture and Water, Riyadh, Saudi Arabia.

Chaudhary, S.A. and A.A. Al Jowaid. 1999. *Vegetation of the Kingdom of Saudi Arabia*. Ministry of Agriculture and Water, Riyadh, Saudi Arabia.

Collenette, S. 1999. *Wildflowers of Saudi Arabia*. National Commission for Wildlife Conservation and Development, Riyadh, Saudi Arabia.

Dixon, M.D. and M.G. Turner. 2006. Simulated recruitment of riparian trees and shrubs under natural and regulated flow regimes on the Wisconsin River, USA.*River Res. Appl.,* 22: 1057-1083.

El-Demerdash, M.A., A.K. Hegazy and A.M. Zilay. 1994. Distribution of the plant communities in Tihamah coastal plains of Jazan region, Saudi Arabia.*Plant Ecol.,*112: 141-151.

Ellery, W.N., K. Ellery, K.H. Rogers, T.S. McCarthy and B.H. Walker. 1993. Vegetation, hydrology and sedimentation processes as determinants of channel form and dynamics in the northeastern Okavango Delta, Botswana. *Afr. J. Ecol.,* 31: 10-25.

Good, R. 1974. *The geography of the flowering plants*. (4th Ed) Longman Group Limited, London.

Graf, W. L. 2006. Downstream hydrologic and geomorphic effects of large dams on American rivers. *Geomorphology*, 79(3-4): 336-360.

Grumbine, R.E. and J. Xu. 2011. Mekong hydropower development. *Science,* 332: 178-179.

Hammer, O., D.A.T. Harper and P.D. Rayan. 2001. Paleontological StatisticsSoftware: Package for Education and Data Analysis. *Paleonotological Electronica,* 4(1):

Heneidy, S.Z. and L.M. Bidak. 2001. Biodiversity of the plant species in Bisha, Asir region, southwestern Saudi Arabia. *Pak. J. Biol. Sci.,* 4: 1323-1330.

Hill, M.O. 1979. TWINSPAN-A FORTRAN computer program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ithaca, New York, USA: Section of Ecology and Systematics, Cornell University.

Ilyas, M., R. Qureshi, M. Arshad and S.N. Mirza. 2013a. A Preliminary checklist of the vascular flora of Kabal Valley, Swat, Pakistan.*Pak. J. Bot.,* 45(2): 605-615.

Ilyas, M., R. Qureshi, N. Akhtar, M. Munir and Z. Haq. 2015. Vegetation analysis of Kabal valley, district Swat, Pakistan using multivariate approach.*Pak. J. Bot.,* 47: 77-86.

Ilyas, M., R. Qureshi, N. Akhtar, Z. Haq and A.M. Khan. 2018. Floristic diversity and vegetation structure of the remnant subtropical broad leaved forests from Kabal valley, Swat, P.*Pak. J. Bot.,* 50(1): 217-230.

Ilyas, M., R. Qureshi, Z.K. Shinwari, M. Arshad, S.N. Mirza and Z. Haq. 2013b. Some ethnoecological aspects of the plants of qalagai hills, Kabal valley, swat, Pakistan.*Int. J. Agric. Biol.,* 15(5): 801-810.

James, J.J., R.L. Tiller and J.H. Richards. 2005. Multiple resources limit plant growth and function in a saline-alkaline desert community.*J. Ecol.,* 93: 113-126.

Khan, A.M., R. Qureshi, M.F. Qaseem, M. Munir, M. Ilyas and Z. Saqib. 2015. Floristic checklist of district Kotli, Azad Jammu & Kashmir.*Pak. J. Bot.,* 47(5): 1957-1968.

Krueger-Mangold, J.M., R.L. Sheley and T.J. Svejcar. 2006. Toward ecologically-based invasive plant management on rangeland. *Weed Sci.,*54: 597-605.

Li, J., S. Dong, M. Peng, X. Li and S. Liu. 2012. Vegetation distribution pattern in the dam areas along middle-low reach of Lancang-Mekong river in Yunnan province, China. Front. *Earth Sci.,* 6: 283-290.

Mahmoud, S.H. and A.A. Alazba. 2015a. Hydrological response to land cover changes and human activities in arid regions using a geographic information system and remote sensing. *PloS one,* 10: 1-19.

Mahmoud, S.H. and A.A. Alazba. 2015b. The potential of in situ rainwater harvesting in arid regions: developing a methodology to identify suitable areas using GIS-based decision support system. *Arab J. Geosci.,* 8: 5167-5179.

Mahmoud, S.H. and A.A. Alazba. 2015c. Geomorphological and geophysical information system analysis of major rainwater-harvesting basins in Al-Baha region, Saudi Arabia. *Arab J. Geosci.,* 8: 9959-9971.

Mahmoud, S.H., F.S. Mohammad and A.A. Alazba. 2015. Delineation of potential sites for rainwater harvesting structures using a geographic information system-based decision support system. *Hydrol. Res.,* 46: 591-606.

Margalef, D.R. 1958. Information theory in ecology. *Gen. Syst.,* 3: 36-71.

Merritt, D.M. and E.E. Wohl. 2006. Plant dispersal along rivers fragmented by dams. *River Res. Appl.,* 22: 1-26.

Mrvic, V., L. Kostic-Kravljanac, D. Cakmak, B. Sikiric, B. Brebanovic, V. Perovic and M. Nikoloski. 2011. Pedogeochemical mapping and background limit of trace elements in soils of Branicevo Province (Serbia). *J. Geochem. Explor.,* 109: 18-25.

Nilsson, C. and K. Berggren. 2000. Alterations of riparian ecosystems caused by river regulation: dam operations have caused global-scale ecological changes in riparian ecosystems. How to protect river environments and human needs of rivers remains one of the most important questions of our time. *Bio Science,* 50: 783-792.

Osman, A. K., F. Al-Ghamdi and A. Bawadekji. 2014. Floristic diversity and vegetation analysis of Wadi Arar: A typical desert wadi of the northern border region of Saudi Arabia.*Saudi J. Biol. Sci.*,21(6): 554-565.

Qureshi, R. 2012.*Flora of Nara Desert, Pakistan*. Nova Publishers/Nova Science Publishers.

Qureshi, R., H. Shaheen, M. Ilyas, M. Wasim and M. Munir. 2014. Phytodiversity and plant life of Khanpur dam, Khyber Pakhtunkhwa, Pakistan.*Pak. J. Bot.*, 46(3): 841-849.

Raunkiaer, C. 1937. *Plant Life Forms*. The Clarendon Press.

Sallam, A.S. 2002. Micronutrients status of Mollisols (southwestern mountainous region, Saudi Arabia). *J. Saudi Soc. Agric. Sci.*, 1: 1-22.

Schaeffer, S.M. and R.D. Evans. 2005. Pulse additions of soil carbon and nitrogen affect soil nitrogen dynamics in an arid Colorado Plateau shrubland.*Oecologia*,145: 425-433.

Shannon, C.E. and W. Weiner. 1963. *The Mathematical Theory of Communication*. University of Illinois Press, Urbana, USA.

Simpson, E.H. 1949. Measurements of diversity. *Nature*,163: 688.

Stave, J., G. Oba, N.C. Stenseth and I. Nordal. 2005. Environmental gradients in the Turkwel riverine forest, Kenya: hypotheses on dam-induced vegetation change.*For. Ecol. Manage.*, 212: 184-198.

Sun, R., W.Q. Deng, X.Z. Yuan, H. Liu and Y.W. Zhang. 2014. Riparian vegetation after dam construction on mountain rivers in China.*Ecohydrology*,7: 1187-1195.

Tealdi, S., C. Camporeale and L. Ridolfi. 2011. Modeling the impact of river damming on riparian vegetation. *J. Hydrol.*, 396: 302-312.

Thomson, J.R., D.D. Hart, D.F. Charles, T.L. Nightengale and D.M. Winter. 2005. Effects of removal of a small dam on downstream macroinvertebrate and algal assemblages in a Pennsylvania stream. *J. North Am. Benthological Soc.*, 24: 192-207.

Ward, J.H. 1963. Hierarchical grouping to optimize an objective function. *J. Am. Stat. Assoc.*, 58: 236-244.

Yeomans, J.C. and J.M. Bremner. 1988. A rapid and precisemethod for routine determination of organic carbon in soil. *Commun. Soil Sci. Plant Anal.*, 19: 1467-1476.

(Received for publication 23 August 2017)