Table S1. Macroinvertebrate funtional traits and states (coded) (modified from Poff et al., 2006 [35]).

trait	Trait state	Code
Voltinism	Semivoltine	Volt1
	Univoltine	Volt2
	Bi- or multivoltine	Volt3
Adult flying strength	Weak (e.g.,cannot fly into light breeze)	Flgt1
	Strong	Flgt2
Shape	Streamlined (flat, fusiform)	Shpe1
	Not streamlined (cylindrical, round, or bluff)	Shpe2
Size at maturity	Small (< 9 mm)	Size1
	Medium (9–16 mm)	Size2
	Large (>16 mm)	Size3
Habit	Burrow	Habi1
	Climb	Habi2
	Sprawl	Habi3
	Cling	Habi4
	Swim	Habi5
	Skate	Habi6
Trophic habit	gatherer	Trop1
	filterer	Trop2
	Scraper	Trop3
	Predator	Trop4
	Shredder	Trop5

Table S2. Key factors selection of alpha diversity indices using multiple linear regression (MLR) and forward selection. PO_4-P = phosphate, SiO_2 = Silicon dioxide, NO_3-N = ammonia nitrogen, Cl = calcium ion, WT = water temperature, AMT = Annual Mean Temperature, AP = Annual Precipitation, PS = Precipitation Seasonality, MDR = Mean Diurnal Range, MEM = Moran's Eigenvector Map.

alpha diversity indices	Selected variables	Adj. R^2	F	*P*
Taxonomic alpha diversity				
Local environmental	Depth, Salinity, PO_4-P, SiO_2	0.392	6.166	0.001
Land use	% Shrub, % urban	0.112	3.511	0.040
Climatic	AMT, AP, PS	0.331	7.596	<0.001
Spatial	MEM2, MEM5, MEM6, MEM11	0.394	7.500	<0.001
Functional alpha diversity				
Local environmental	Salinity, NO_3-N, PO_4-P, Hardness, Cl	0.278	4.079	0.005
climatic	AMT, MDR, AP	0.164	3.547	0.024
spatial	MEM1, MEM3, MEM4, MEM6, MEM10, MEM11	0.218	2.861	0.023
Phylogenetic alpha diversity				
Local environmental	Depth, Salinity, WT, NO_3-N, PO_4-P	0.431	7.064	<0.001
Land use	% Shrub, % Water area	0.223	6.760	0.003
Climatic	AP, PS	0.259	7.972	0.001
Spatial	MEM1, MEM3, MEM4, MEM6, MEM8, MEM12	0.497	6.648	<0.001

Table S3. Key factors selection of beta diversity indices using db-RDA and forward selection. TD = taxonomic diversity, FD = functional diversity, TD = phylogenetic diversity, WT = water temperature, SiO_2 = Silicon dioxide, PO_4-P = phosphate, NO_3-N = ammonia nitrogen, AMT = Annual Mean Temperature, AP = Annual Precipitation, PS = Precipitation Seasonality, MDR = Mean Diurnal Range, MEM = Moran's Eigenvector Map.

beta diversity indices	selected variables	Adj. R^2	F	*P*
Taxonomic total beta diversity				
Local environmental	Salinity, WT, Hardness, SiO_2	0.612	16.788	<0.001
Land use	% urban	0.088	4.878	0.012
Climate	AMT, AP, PS	0.352	8.245	<0.001
Spatial factors	MEM1、MEM2、MEM6	0.500	14.218	<0.001
Taxonomic turnover				
Local environmental	Salinity, WT, Hardness	0.593	20.445	<0.001
Land use	% Shrub, % urban	0.148	4.465	0.013
Climate	AMT, MDR, PS	0.300	6.701	<0.001
Spatial factors	MEM1、MEM6、MEM10	0.490	13.808	<0.001
Taxonomic nestedness				
Local environmental	SiO_2, PO_4-P	0.217	6.547	<0.001
Spatial factors	MEM2、MEM6	0.173	5.179	0.003
Functional total beta diversity				
Local environmental	Salinity, WT, NO_3-N	0.290	6.435	<0.001
Climate	AMT	0.113	6.121	0.002
Spatial factors	MEM1, MEM8	0.114	3.571	0.009
Functional turnover				
Local environmental	Salinity, WT, NO_3-N	0.302	6.773	<0.001
Land use	% Shrub	0.069	3.978	0.033
Climate	AMT	0.126	6.754	<0.001
Spatial factors	MEM1、MEM8	0.220	6.654	<0.001
Functional nestedness				
Local environmental	NO_3-N	0.167	9.007	0.003
Phylogenetic turnover				
Land use	% Shrub	0.084	4.659	0.034
Phylogenetic nestedness				
Spatial factors	MEM1、MEM10	0.134	4.091	0.022