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EXTENDED ABSTRACT

Investigating the Effects of Land Use/Land Cover Composition on River Water Quality

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1. Introduction

Point and nonpoint sources of pollution both affect water quality (Wang and Choi, 2005). Among the factors of non-point source, land use and land cover are the most important resources, which numerous research studied relationships between land use and water quality in different watersheds (Jun, 2011; Seeboonruang, 2012; Jun, 2013). There is a significant correlation between land use and water quality (Su et al. 2012; Wan et al., 2014) and this relationship is influenced by types and their spatial patterns land use.

Landscape metrics have been used since 1980s to determine the degree of heterogeneity of spatial and landscape structure, including composition and configuration. Three features of the landscape are structure, composition and configuration based on landscape ecology (Amiri et al., 2016; Forman and Godron, 1986), which can be measured and analyzed based on the specific landscape metrics (Rutledge, 2003). Landscape structure has a great influence on the flow of nutrients at the catchment area (Amiri and Nakane 2009; Turner and Rabalais 2003). Due to the fact that non-point pollution has contributed to water pollution, the effect of non-point sources due to the change in landscape patterns is very important (Basnyat et al. 1999; Bhaduri, 2000). Moreover, landscape shows spatial heterogeneity of specific basin, and different patterns can be observed at various scales (Herold et al., 2005). A better understanding of the relationship between landscape metrics and water quality indicators can increase efforts in water management and research (Kearns et al., 2005).

2. Methodology

Five river water quality variables, including EC, Cl, Na, Mg and SAR, which are related to 32 hydrometric stations in Ardabil province, were obtained from the regional water authority. Land use/land cover map was acquired from the Ardebil land use planning. Landscape structure metrics including Shape, Fractal Dimension Index, Perimeter-Area Ratio, Related Circumscribing Circle, and Contiguity indices were calculated by the Fragstate 4.2 at Class level for each land use category. Geographic Information System (GIS) and the topographic map (scale 1: 50000) were used to determine the boundaries of 32 basins. For statistical analysis, all the water quality variables were first tested using a Shapiro test with a P value of less than 0.05 (in the case of non-normal distribution, data was converted using the Box-Cox method). Spearman correlation test was used to determine correlation between water quality variables and land use characteristics. Multivariate Linear regression modeling (MLR) was used to determine relationship between water quality variables and land use characteristics and landscape metrics. For multivariate regression test, 70% of available data was used. Four simple regression models, including power, exponential and logarithmic, and linear for water quality variables were fitted and evaluated. Akaike Information Criteria (AIC) was used to determine most appropriate model. Collinearity between independent variables in obtained models was investigated by variance inflationary

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factor (VIF). This factor examines correlation between two independent variables. For a given water quality variables, the appropriateness of a given regression model was determined based on r2 and P statistics. Finally, in order to validation the appropriate models, model absolute error, model efficiency and model relative error metrics were used for this purpose.

3. Results and discussion

Normality test was examined by Shapiro's test, according to which all the water quality data were transformed using by Box-Cox. The results of Spearman correlation test showed that out of seven land use/land cover categories, the percent area of dry farming has a direct significant relationship with average concentration of water quality variable including EC, Cl, Na, Mg and SAR.. Four regression model types, including linear, power, exponential and logarithmic models were used for fitting the models, by which the relationship between water quality variables and land use characteristics and landscape metrics are explained. The Akaike Information Criteria was then calculated to determine optimal model for the each of water quality parameters. The results of Akaike Information Criteria are shown in Table 1.

Table 1. Akaike Model Results

Variable	Linear	Power	Exponentia;	Logarithmic
EC	1.01E-13	0.0027	6.2E-06	0.9972
Cl	0.0367	0.9631	0.00011	6.2E-11
Mg	0.033	0.961	0.0059	6.99E-15
Na	0.0003	0.999	0.0005	0
Sar	0.318	0.6815	1.78E-05	1.66E-16

Having determined the optimal model for the each of water quality parameters, a multivariable linear regression model was fitted using with stepwise approach. Table 2 shows the results of fitting the most appropriate model type for the each of river water quality parameters. The results of analysis of variance showed a significant relationship between water quality variables and independent variables at significance level of 0.05. The values of variance inflation factor were also calculated for identifying whether there is any collinearity between independent variables. The values of this factor for all the fitted models (Table 2) indicated that there was no multiple collinearity among independent variables. Moreover, the significant values of t for all the independent variables and for all the fitted models are less than 0.05. It can be stated that the coefficients of independent variables in the regression models are opposite zero and independent variables of model have sufficient reliability.

Table 2. Regression Model Results for each water quality variable

Model		Coefficients						Collinearity Statistics	
Model type	Variable	B	Std. Error	Beta	R2	t	Sig.	Tolerance	VIF
Mg	(Constant)	-.010	.092		0.875	-.108	.915		
	CONTIG R2	1.443	.323	.561		4.463	.000	.871	1.148
	CONTIG Other	-7.692	1.641	-.571		-4.687	.000	.928	1.077
	R2	-.202	.074	-.356		-2.736	.014	.813	1.231
Na	(Constant)	-.248	.223		0.912	-1.115	.280		
	Df	.030	.004	.706		6.849	.000	.927	1.079
	PARA Other	.009	.002	.609		5.697	.000	.862	1.160
	FRAC Ir	-.621	.252	-.271		-2.468	.024	.815	1.227
EC	(Constant)	.201	.007		0.903	30.859	.000		
	FRAC R2	-.038	.008	-.548		-4.997	.000	.957	1.045
	Or	.000	.000	-.486		-4.496	.000	.985	1.016
	PARA Ur	-1.426	.448	-.347		-3.183	.006	.966	1.035
	PARA Df	-1.522	.639	-.261		-2.383	.030	.955	1.048
Cl	(Constant)	-.010	.120		0.764	-.087	.932		
	CONTIG R2	1.813	.507	.545		3.578	.002	.994	1.006
	Or	-.386	.119	-.496		-3.255	.004	.994	1.006
Sar	(Constant)	-.152	.133		0.864	-1.143	.268		
	CIRCLE R2	2.034	.356	.681		5.718	.000	.993	1.007
	PARA Or	.196	.049	.478		4.015	.001	.993	1.007

In order to validate the fitted models for the each of water quality parameter, model absolute error, model efficiency and model relative error indices were calculated (Table 3).

Table 3. Water quality variables verification results

Variable	absolute error of the model				performance analysis of model			relative error of model			
	PDIFF	MAE	ME	RMSE	R2	CE	IA	RAE	MARE	MRE	RVE
EC	-0.002	0.0059	0.002	0.0072	0.778	0.746	0.933	0.5304	0.0154	0.011	0.004
Cl	0.083	0.151	-0.0006	0.197	0.778	0.775	0.937	0.479	0.397	0.231	-0.001
Mg	-0.014	0.119	-0.0469	0.178	0.821	0.808	0.946	0.372	0.3309	0.108	-0.094
Na	-0.689	0.445	-0.0866	0.518	0.546	0.362	0.847	0.834	1.127	-0.857	-0.174
Sar	-0.17	0.308	-0.2916	0.3601	0.809	0.422	0.836	0.939	0.873	0.733	-0.588

4. Discussion and Conclusions

The present study was carried out using geographic data and water quality on 32 watersheds in Ardebil province. The MLR modeling was based on a stepwise approach to develop relationship between water quality data, land use/land cover characteristics and landscape metrics at class level. The results of this study showed that land scape metrics can explain more than 80% of variance of water quality variables in Ardabil provinces. Johnson et al., 2007 showed that landscape metrics represent the 56 percent of the variance of water quality changes. Moreover, Xiao et al., 2007 demonstrated landscape metrics showed about the 77% of the variance of water quality variables. Out of the landscape metrics, the Contiguity Index has the highest r^2 value in comparison with other metrics. Para and Fractal indices also have a greater influence on the variance of water quality variables. Contiguity index and Fractal dimension index for rangeland, and other land use/ land cover categories have significant relationships with the mean measure of Cl, Mg and EC concentrations at $p\leq 0.05$ level.

The findings of the present study show consistency with those of Amiri and Nakane (2009) and Zhou et al. (2012). Moreover, it indicated that dry farmland category have contributed to river water quality, which are in line with those of Huashan et al., (2016) and also and urban Xiao et al., (2012) in relation to the contribution of agricultural land use and urban land uses on river water quality, respectively. The results of regression analysis of this study also showed that landscape metrics can play a significant role in in predicting river water quality, which is consistent with the findings of Xiao et al., (2012) and Amiri and Nakane (2009).

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