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Adsorption of Herbicides on eight Agricultural Soils

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ABSTRACT

A study was conducted to determine the differences in the adsorption behavior of three pesticides, nonionic atrazine [2-chloro-4-ethyl amino- 6-isopropylamino-1,3,5,-triazine], an ionic picloram [4-amino-3,5,6-trichloropicolinic acid] and anilide group propanil [N-3,4-dichlorophenyl) propanaamide] on eight agricultural soil samples. Data from batch equilibrium method revealed that the adsorption of herbicides on the selected soil samples followed the first order rate law. Propanil exhibited the faster rate of accumulation with 24.82% adsorption on the soil solid matrix after 0.5h as compared to that for picloram and atrazine 18.98%, 13.9% respectively. The standard error (S.E) values were from 0.034 to 1.000, 0.007 to 0.983 and from 0.691 to 0.859 for atrazine, picloram and propanil respectively. Linear, Freundlich and Langmuir models were used to describe the adsorption of the three pesticides. Values of distribution coefficient (Kd) indicated moderate to low adsorption for atrazine (mean calculated Kd: 1.1597 mlg-1) while slightly higher for picloram (mean calculated Kd: 1.5779 mlg-1) and highest for propanil adsorption (mean calculated Kd: 12.662 mlg-1) and consequently there is no considerable risk of ground water contamination. Wide variation in adsorption affinities of the soils to the pesticides was observed, Kd values for atrazine varied between 0.951 and 1.53 mlg-1 while for picloram between 0.99 and 2.309 and for propanil between 9.044 and 16.56 mlg-1.

Introduction

Pesticides have become an indispensable component of modern agricultural systems and are being increasingly used to insure the production of an adequate supply of food and hence the quality of produce. However, the occurrence of herbicides in ground water has become an important environmental concern in many countries (1-5).

Adsorption-desorption is one of the key processes affecting the fate of agrochemicals in the sediment- water environment, so thorough understanding of adsorption is paramount for the prediction of pesticides movement in soils and aquifers(6-7). The sorption of uncharged organic compounds by soils has been shown to be highly correlated with soil organic carbon (OC) content (8-12) and the water solubility of the pesticides in question (13-16).

Atrazine belongs to ionic - basic herbicides is a selective triazine herbicide used to control broadleaf and grassy weeds of Christmas trees and other crops. Atrazine is moderate to highly mobile in soil and does not adsorb strongly to soil particles. The half life of atrazine is 60 to 100 days and it has high potential for groundwater contamination (17-20).

Picloram; is anionic herbicide is used to control unwanted woody plants and to prepare sites for planting trees and used to control broad-leaf plants and trees (21). Its adsorption involved ionic interaction with positive charges in soil and also the less energetic Van der Waals forces and charge transfer (22-25).

Propanil is an herbicide which belongs to an anilides group (Agrochemical with a secondary amide linkage) which is widely used for weed control in agricultural crops as a consequence of their widespread use, the residue levels ranging from 0.1 to 10 µg l-1 have been detected in surface water (26-28).

Since information on the sorption behavior of pesticides in soils is essential in predicting their

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leaching potential and contamination of groundwater and no data are available in literature for sorption kinetics equilibrium parameters of the three pesticides on agricultural soil, studies were conducted on the sorption of the three pesticides determining their environmental fate and understanding their soil dynamic.

Materials and methods

Soils: Fresh soil samples were taken from plough layer (0-15 cm depth), after removal of stones and debris, air dried under shade, ground then sieved through 2mm sieve and stored in black plastic container in dark (29-30). The eight agricultural soil samples were representing a range of physico-chemical properties. Subsamples of homogenized soils were analyzed for moisture content, organic matter content, particle size distribution, texture, pH, loss on ignition and exchangeable basic cations (Table 1 a & b).

Pesticides: Analytical grad substituted atrazine, picloram and propanil were purchased from Riedal-de Haen, Sigma-Aldrich company.

All chemicals used were of analytical grade reagents and used without pre-treatments. Standard stock solutions of the pesticides were prepared in deionised water.

Adsorption Experiments: Adsorption of pesticides from aqueous solution was determined at ambient laboratory temperature (25±1 C°) employing a standard batch equilibrium method (29-30) Duplicate air-dried soil samples were equilibrated with different pesticide concentrations (2, 5, 10, and 15 µg ml-1) were for the three pesticide at the soil solution ratios 4:10, 4:8, 1:10 for atrazine, picloram and propanil respectively, in 16 ml glass tube fitted with Teflon-lined screw caps. The samples plus blanks (no pesticide) and control (no soil) were thermostated and placed in shaker for 0.5, 1, 3, 6, 6, 9, 12, 24, 48 and 72h for atrazine and picloram and 0.5, 1, 3, 6, 8, 10, 12, 24, and 48h for propanil. The tubes were centrifuged for 20 min. at 3500 rpm. One ml of the clear supernatant was removed and analyzed for the pesticide concentration (31).

Pesticide identification was done by PerkinElmer series 200 USA family high performance liquid chromatography (HPLC) equipped with a changed loop (5µl for atrazine, 20µl for picloram and 10µl for propanil, C18 reversed phase column, flow rate 1.4 ml min-1 for atrazine and propanil while 1.0 ml min-1 for picloram, and a variable wave length UV detector at wavelength 226, 220 and 248 nm for atrazine, picloram and propanil respectively. Separation of atrazine in aqueous phase was achieved with a mobile phase of 60% acetonitrile and 40% water (with 1mmol ammonium acetate) and separation of picloram in aqueous phase was achieved with a mobile phase of 40% acetonitrile and 60% water (acidified with 0.1% phosphoric acid).While the separation of propanil was achieved with mobile phase of 60% acetonitrile and 40% water. Each sample was injected twice to determine the pesticide content by integrating the obtained peak with the respective standard pesticides. The pesticide content was average of two measurements, with no more than 5% deviation between the measurements.

Data analysis

Adsorption Kinetics

The rate constants for adsorption of each pesticide on soils were calculated using the first order rate expression (31):

$$Log(C_\circ - C_t) = \log C_\circ - \frac{k}{2.303}t \qquad (1)$$

Where k is the rate constant (hour-1), t the time (hour), Co the concentration of pesticide added (µg ml-1) and Ct the amount adsorbed (µg ml-1) at time t. In all cases, first order equation provided satisfactory fit for the data as shown by a linear plots of log (Co – Ct) against t (Figures 1, 2, and 3).

Adsorption Isotherms

During adsorption studies, equilibrium concentration of pesticide in solution (Ce) was determined by direct analysis of the solution and amount of pesticide adsorbed on soil (Cs) was computed by the difference between the initial and the equilibrium concentration in the aqueous phase. Analysis of control samples showed that, in the absent of soil, pesticide concentration remained constant during the course of the batch experiments. The adsorption data were used to construct the following linear forms of isotherms (31).

Linear Adsorption Coefficient (Distribution Coefficient)

$$C_s = K_d C_e \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The distribution coefficient (Kd) was calculated by taking the ratio of adsorption concentration in soil (Cs) and equilibrium concentration in solution (Ce), and averaged across all equilibrium concentration to obtain a single estimate of Kd (Table 3).

Freundlich Adsorption Isotherm: Adsorption isotherm parameters were calculated using the linearized form of Freundlich equation(32):

$$LogC_s = \log K_F + \frac{1}{n}\log C_e \quad \ldots\ldots\ldots(3)$$

Cs and Ce were defined previously, KF is Freundlich adsorption coefficients, and n is a linearity factor, it is also known as adsorption intensity, 1/n is the slope and logKF is the intercept of the straight line resulting from the plot of logCs versus logCe.

The values of KF and 1/n calculated from this regression equation showed that Freundlich adsorption model effectively describes isotherms for the pesticides in all cases.

Langmuir Adsorption isotherm

Data from the batch adsorption conform to Langmuir equation(33):

$$\frac{C_e}{C_s} = \frac{1}{C_m K_L} + \frac{C_e}{C_m} \quad \ldots\ldots\ldots (4)$$

Cm is the maximum amount of pesticide adsorbed (adsorption maxima, µg ml-1), it reflects the adsorption strength and KL is the Langmuir adsorption coefficient, binding energy coefficient.

Results and Discussion

Adsorption Rate: Data in Table 2 showed that adsorption of the pesticides in all cases followed first order rate law as reported in literature(34,35) Values of rate constants for adsorption of the studied pesticide on the selected soil samples were in the following order propanil< picloram< atrazine. The calculated k values were oscillated from 0.581 to 1.6256, 0.5394 to 1.9287 and from 1.3217 to 2.8545 for propanil, picloram and atrazine respectively. Thus propanil has higher affinity to the selected soil samples than other two pesticides. This can be attributed to the value of octanol water partition coefficient KOW. The logKOW is 2.61 for atrazine, 2.28 for propanil and very low for picloram. Experimentally, we found that propanil exhibited the faster rate of accumulation with 24.82 % adsorption on the soil solid matrix after 0.5 hours as compared for picloram 18.98 % and atrazine 13.9 %. The standard error S.E values were from 0.034 to 1.000, 0.007 to 0.983 and from 0.691 to 0.859 for atrazine, picloram and propanil respectively.

Adsorption Isotherms: Data in Table 3 indicated that the linear model not fitted properly most experimental data with the three pesticides. The non-linear adsorption isotherms might be expected for the compounds for which competition for a limited number of cation exchange sites contributes significantly to adsorption process. The magnitude of the Kd values is indicative of moderate to low adsorption for atrazine (mean Kd (calc) =1.1597 mlg-1) while slightly higher adsorption for picloram (mean Kd(calc) =1.5779 mlg-1) and the highest for propanil (mean Kd (calc) =12.665 mlg-1). These findings are in agreement with the hydrophobicity of the herbicides as represented by Kow values, and they support the comment in literature about the use of the octanol-water partition coefficients to predict the adsorption of the organic compound in soils (36).

Data in Table 3 indicated that, Freundlich adsorption model effectively describes isotherm for both atrazine and picloram. On the all eight soil samples, with regression factor R2 > 0.9 (except S4 with picloram). KF is known as adsorption capacity. This can be considered as a measurement of the relative adsorption capacity because it is the value of Cs when Ce is the unity. Values of KF for atrazine adsorption varied between 0.831-1.08 mlg-1 while for picloram 0.9612-1.603 mlg-1.The differences in the behavior of the herbicides toward the same soil samples is due to the difference in the type of interaction of the pesticides with the soil due to the chemical and physical nature of pesticide and the characteristics of the studied soil sample. The colloidal surface of the most agricultural soils have a net negative charge and thus have affinity for positively charged molecules, but not much affinity for negatively charged molecules i.e. herbicides constituents(37). Values for atrazine in the selected soil sample were in the following order S5> S1> S8> S6> S7> S3> S4 >S2, while for picloram were in the following order S6> S4> S7> S3> S2> S1> S8 >S5. In adsorption study for atrazine, the values of n were less than unity for the eight soils indicating a non-linear relationship between concentration of atrazine and its sorption to these soils. A linear relationship between concentration of picloram, and its adsorption to these soils n<1, (except S4, S6). The variable slopes of the adsorption isotherms obtained for different soil systems studied will reveal that the adsorption on soil is a complex phenomenon involving different types of adsorption sites with different surface energies (38-40). However, they were dependent on the soil properties with a significant negative trend for being affected by the organic matter of the soil.

Data in Table 3 indicated, langmuir adsorption model effectively describes isotherm for propanil on all soil samples with good regression factor R2 (R2 ≥ 0.736). Values of adsorption capacity Kl ranged from 0.1383- 0.483mlg-1.The maximum amount of propanil adsorption (Cm) ranged from 55.55-161 µg g-1. Values of Kl can vary among soils due to the quantities and composition of soil components. Values of Kl for adsorption of propanil in the selected soil samples were in the order of S5> S1 > S3 > S6> S8> S2> S4> S7. Pesticides adsorption on an agricultural soil conducted by the other researchers has demonstrated that sorption coefficient is not constant but rather changes with soil properties (41-43). The different values of adsorption coefficients for the same pesticides with different soils is due (to some extent) to soil organic carbon(44,45) and clay content(8). The different values of adsorption coefficients for the same pesticides with different soils is due (to some extent) to soil organic carbon (44, 45) and clay content (8).

The batch kinetics experiments were used to differentiate the behavior of three pesticides in eight agricultural soil samples. The adsorption studies demonstrated that propanil has stronger affinity to all the selectedsoil samples than atrazine, picloram and the soils varied widely in their adsorption capacities for atrazine, picloram and propanil. We have further found that soil OC and clay content and the chemical nature of the constituents determined the adsorption affinity of the soil. Since the current understanding the role of the chemical composition of soil OC in determining pesticide fate and behavior in soils of our country is in adequate. Efforts must continue to develop better understanding of role of chemistry of soil organic carbon in governing pesticide adsorption and explaining different types of soil pesticide interactions.

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Table 1 (a): Some physico-chemical properties of the selected soil samples.

Soil	OM %	Moisture%	LossOn ignition%	C EC meq100g^{-1}	E.C*10^{-2} sm^{-} inD.w	pH	
						In D.W	in $CaCl_2$
S_1	2.926	1.761	5.442	23.552	0.393	6.664	6.050
S_2	1.767	3.190	4.662	30.296	0.321	7.226	7.020
S_3	1.762	3.469	5.223	38.155	0.466	7.652	7.040
S_4	1.712	2.144	5.726	37.294	0.525	7.447	7.010
S_5	3.211	2.836	7.646	44.828	0.613	7.528	6.946
S_6	2.229	1.425	4.916	39.936	0.517	7.055	6.57
S_7	2.357	2.076	5.382	37.428	0.425	7.547	6.798
S_8	2.656	2.783	6.173	40.501	0.462	6.992	6.576

Table 1 (b): Particle size distribution and the texture of the selected soil samples.

Soil	Location	X(m) Latitudinal	Y(m) Longitudinal	Sand %	Clay %	Silt %	Texture
S_1	Kirkuk	$44^+24.305^-$	$35^+29.269^-$	48.403	14.80	36.801	Loam
S_2	Sulaimani	$45^+22.012^-$	$35^+33.612^-$	8.201	42.202	49.630	Silty Clay
S_3	Qalhadza	$45^+07.031^-$	$36^+11.116^-$	29.6	40.6	29.802	Clay
S_4	Duhok	$43^+03.0971^-$	$36^+50.606^-$	4.40	55.20	40.41	Silty Clay
S_5	Aqrah	$43^+50.346l^-$	$36^+43.422^-$	12.42	46.41	41.20	Silty Clay
S_6	Erbil	$44^+04.425^-$	$36^+14.314^-$	22.80	25.52	51.72	Silty Loam
S_7	Halabjh	$45^+57.450^-$	$35^+20.012^-$	13.74	44.910	41.40	Clay loam
S_8	Bekma	$44^+12.219^-$	$36^+39.192^-$	16.32	38.40	45.33	Silty Clay Loam

Table 2: Adsorption rate constants calculated for atrazine, picloram and propanil on the selected soil samples.

Soil	Conc. ppm	Atrazine			Picloram			Propanil		
		K (calc (h^{-1})	S.E	R^2	K (calc (h^{-1})	S.E	R^2	K (calc($h^{-1})$	S.E	R^2
S_1	2	1.478	0.297	0.895	1.161	0.198	0.879	0.781	0.273	0.827
	5	1.725	0.311	0.754	0.881	0.198	0.859	1.104	0.272	0.942
	10	2.043	0.314	0.748	1.399	0.201	0.907	0.916	0.271	0.911
	15	2.011	0.309	0.929	1.787	0.215	0.843	1.626	0.277	0.978
S_2	2	1.385	0.297	0.872	1.572	0.210	0.832	0.667	0.274	0.944
	5	1.559	0.300	0.996	0.770	0.199	0.865	1.083	0.274	0.952
	10	1.945	0.305	0.853	1.489	0.203	0.949	1.060	0.271	0.949
	15	1.810	0.304	0.837	1.134	0.203	0.775	1.350	0.170	0.989
S_3	2	1.599	0.300	0.855	1.372	0.205	0.885	0.639	0.275	0.852
	5	1.668	0.305	0.885	1.182	0.201	0.877	1.006	0.275	0.961
	10	1.745	0.301	0.893	0.720	0.198	0.978	0.802	0.273	0.938
	15	2.058	0.322	0.965	0.780	0.197	0.912	1.446	0.272	0.961
S_4	2	2.035	0.309	0.876	1.987	0.221	0.874	0.581	0.276	0.942
	5	1.818	0.304	0.915	0.909	0.198	0.876	0.909	0.273	0.818
	10	1.570	0.297	0.867	1.826	0.208	0.849	0.907	0.270	0.938
	15	1.973	0.317	0.958	1.197	0.196	0.977	1.216	0.274	0.879
S_5	2	2.337	0.325	0.838	1.589	0.213	0.874	0.607	0.275	0.979
	5	1.944	0.307	0.936	0.797	0.198	0.975	0.839	0.274	0.896
	10	1.843	0.309	0.796	1.600	0.209	0.987	0.685	0.273	0.776
	15	2.855	0.386	0.897	1.364	0.199	0.825	1.010	0.269	0.958
S_6	2	1.624	0.298	0.947	1.921	0.215	0.925	0.617	0.275	0.911
	5	1.541	0.301	0.871	0.798	0.198	0.877	1.022	0.286	0.783
	10	1.528	0.295	0.929	1.826	0.196	0.876	0.986	0.272	0.887
	15	1.808	0.307	0.927	1.101	0.197	0.856	1.341	0.278	0.756
S_7	2	1.400	0.297	0.857	0.894	0.197	0.893	0.930	0.282	0.954
	5	1.584	0.300	0.874	1.010	0.198	0.908	1.049	0.282	0.793
	10	1.478	0.298	0.878	0.583	0.200	0.965	1.091	0.282	0.876

	15	1.663	0.302	0.816	0.539	0.201	0.965	1.177	0.282	0.869
S_8	2	1.322	0.294	0.978	0.865	0.197	0.887	0.652	0.274	0.968
	5	1.716	0.302	0.879	0.851	0.198	0.845	0.932	0.273	0.834
	10	1.419	0.297	0.868	0.986	0.196	0.911	0.785	0.272	0.979
	15	1.689	0.303	0.846	1.089	0.197	0.876	1.141	0.269	0.903
MeanK(h^{-1})		1.755			1.187			0.967		

Table 3: Adsorption isotherm parameters for the linear, Freundlich and Langmuir models to for atrazine, picloram and propanil.

Pesticide	Adsorption model	Parameter	Soils							
			S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
Atrazine	Distr. coffi.	K_d (calc)	1.478	1.149	1.025	1.072	1.047	1.004	0.951	1.530
		S.E	0.745	0.624	0.579	0.772	0.951	0.941	0.746	0.806
		R^2	0.584	0.899	0.931	0.916	0.975	0.841	0.941	0.983
	Freundlich	K_F(mL/g)	1.075	0.831	0.868	0.859	1.081	0.958	0.939	0.989
		S.E	0.361	0.339	0.337	0.344	0.359	0.354	0.353	0.361
		n_f	0.643	0.339	0.559	0.497	0.894	0.913	0.894	0.338
		R^2	0.903	0.923	0.994	0.934	0.997	0.974	0.978	0.951
Piclorm	Distr. coffi.	K_d (calc)	1.530	1.655	1.799	0.990	1.349	1.314	2.309	1.677
		S.E	0.524	0.427	0.432	0.374	0.354	0.470	0.561	0.375
		R^2	0.825	0.765	0.977	0.525	0.614	0.865	0.968	0.846
	Freundlich	K_F(mL/g)	1.040	1.095	1.135	1.414	0.961	1.603	1.336	1.023
		S.E	0.365	0.383	0.380	0.366	0.344	0.395	0.404	0.375
		n_f	0.469	0.485	0.453	3.115	0.492	1.808	0.552	0.339
		R^2	0.987	0.969	0.995	0.762	0.962	0.935	0.987	0.991
Propanil	Distr. coffi.	K_d (calc)	10.41	10.93	14.93	16.07	13.512	16.56	9.044	9.857
		S.E	0.491	0.626	0.626	0.437	0.766	0.824	0.319	0.371
		R^2	-0.109	0.747	-0.133	0.935	0.050	0.543	0.851	0.372
	Langmuir	K_l(mL/g)	0.471	0.249	0.3343	0.138	0.483	0.328	0.138	0.268
		S.E	0.375	0.348	0.1311	0.255	0.345	0.297	0.341	0.358
		C_m (μg/g)	55.56	76.336	82.645	161.29	64.94	92.59	97.09	70.922
		R^2	0.960	0.964	0.842	0.927	0.953	0.969	0.737	0.953

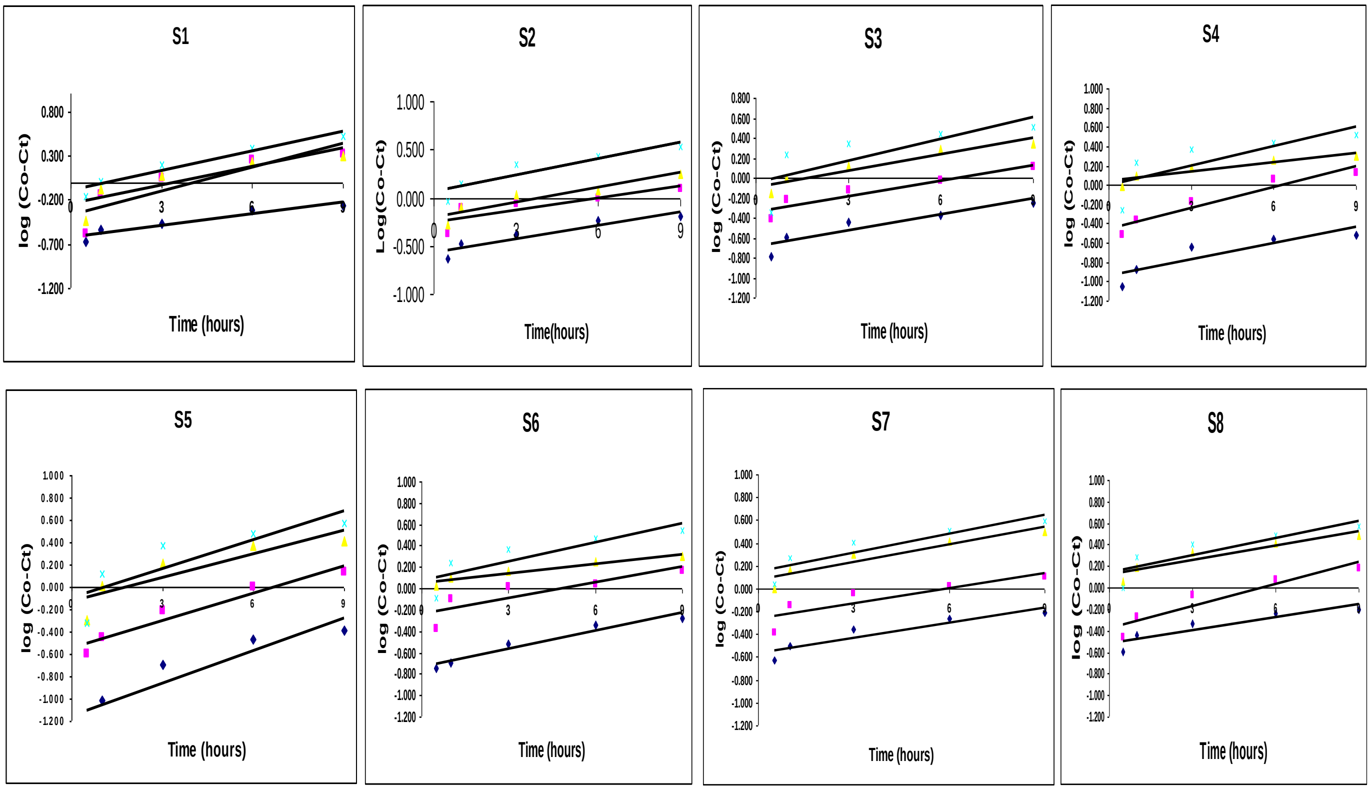


Figure 1: Application of 1st order rate law for atrazine on the selected soil samples(a) S_1, (b) S_2, (c) S_3, (d) S_4, (e) S_5 , (f) S_6 , (g) S_7 and (h) S_8 (♦ 2, ■ 5, ▲10, and x 15 μgml^{-1}).

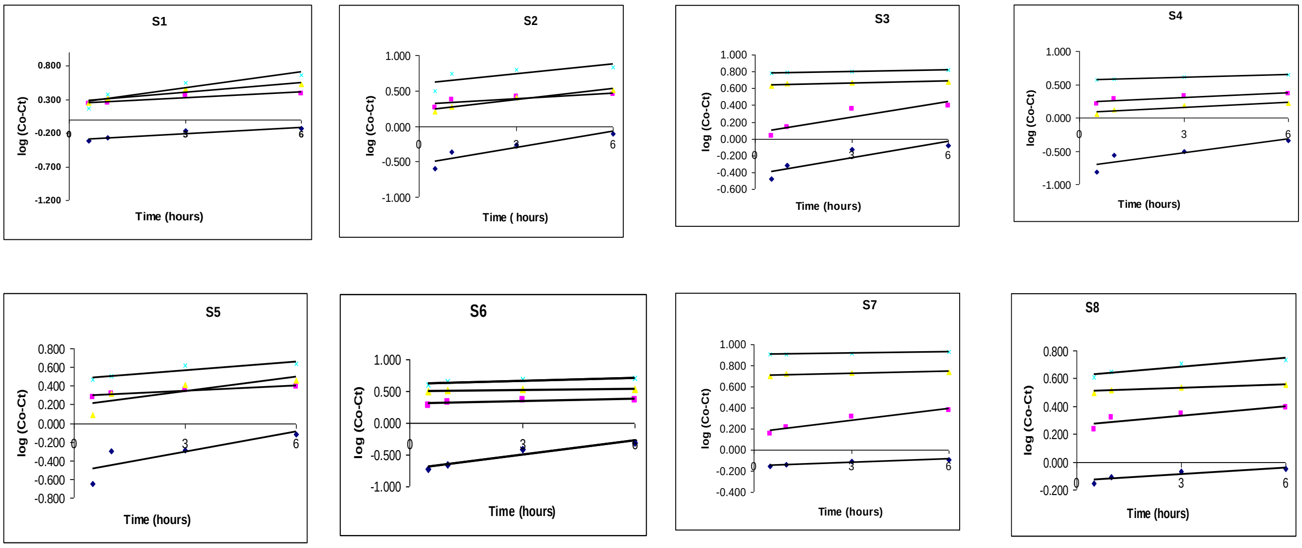


Figure 2: Application of 1st order rate law for picloram on the selected soil samples(a) S1, (b) S2, (c) S3, (d) S4, (e) S5 , (f) S6 , (g) S7 and (h) S8 (♦ 2, ■ 5, ▲10, and x 15 μgml-1).

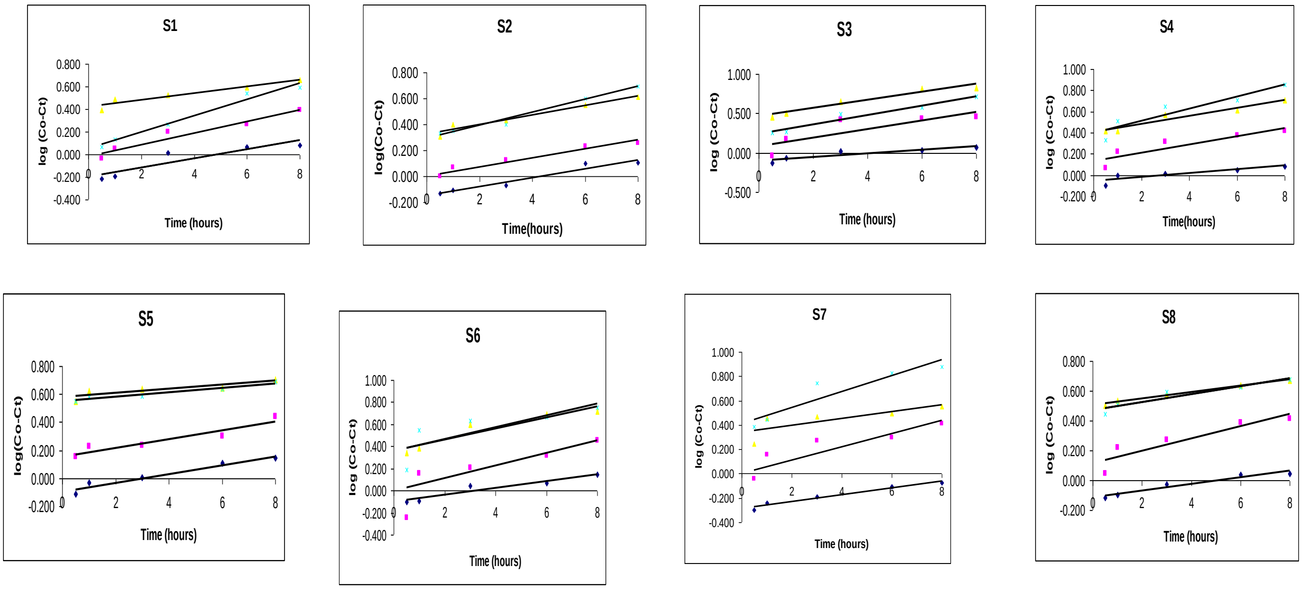
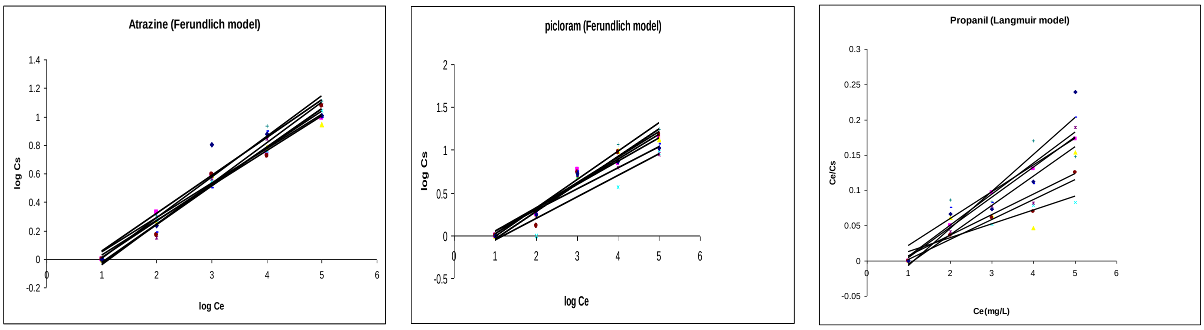


Figure 3: Application of 1st order rate law for propanil on the selected soil samples(a) S1, (b) S2, (c) S3, (d) S4, (e) S5 , (f) S6 , (g) S7 and (h) S8 (♦ 2, ■ 5, ▲10, and x 15 μgml-1).



(a) (b) (c)

Figure 4: Adsorption isotherms for selected soils in (a)atrazine- (b)Picloram (c) Propanil (♦ S1, ■ S2, ▲ S3, x S4, * S5, ●S6, +S7 , -S8).

دراسة الدينمية والحركية لامتزاز المبيدات على ثمانية ترب زراعية

كافية مولود شريف – روناك ميرزا شريف

الخلاصة

يعتبر الإمتزاز احد اهم المفاتيح لفهم و تبيان صفات و خصائص سلوك المبيدات على التربة فى البيئة. أجريت الدراسة الدينمية الحرارية والحركية على ثلاث مبيدات (اترازين ، بايكلورام ، بروبانيل) مختلفة ألصفات لأظهار الفوارق في سلوك إمتزازها على ثمانية نماذج لمواقع مختلفة من ترب زراعية بإستعمال طريقة التوازن الدفعي.

الدراسة اشتملت على بعض أجزاء رئيسية:دراسة بعض الخصائص الفيزيوكيمياوية للتربة مثل (الرطوبة ، الفقدان عند الإشتعال، pH ، الموادالعضوية، التبادل في الأيونات الأساسية الموجبة والسالبة CEC، وقياس حجم الدقائق) للتربة المختارة.الدراسة الحركية أشتملت على إمتزازية المبيدات في التربة حيث أجريت في درجة حرارة 25±1 سيليزية في الظلام و نسبة التربة الى المحلول كانت 4: 10, 4 :8 و 1 : 10 ل(اترازين ، بايكلورام ، بروبانيل) على التوالي.تم قياس أيزوثيرم الإمتزاز في أربعة تراكيز اولية 2، 5، 10، 15 ملغم/لتر لكل من المبيدات المستخدمة. حيث اجريت التجارب لأزمنة مختلفة للوصول الى حالة الأتزان (0.5, 1, 3, 6, 9, 12, 24, 48, 72h . لكل من اترازين و بايكلورام ،بينما لبروبانيل 0.5, 1, 3, 6, 9, 12, 24, 48h) أحتوى محلول خلب (بلانك) على التراب في الماء خالي من مبيد و محلول سيطرة مع المبيد فقط في ماء غير الأيوني سبق وان حضر و عومل بالتطابق مع كل مجموعة من نماذج مجاميع التجربة. أنجز تقدير المبيدات بوساطة جهاز HPLC المجهز بكاشف للأشعة المرئية و فوق البنقسجيةVisible .UV -اما معدل سرعة الإمتزازية لكل مبيد قد قيس بإستعمال قانون السرعة للمرتبة الأولى اذ كان ترتيب ثابت السرعة كالتالى اترازين< بايكلورام< بروبانيل. اظهرت البيانات الامتزازية ان للبروبانيل قابلية اسرع لامتزاز حيث بلغت نسبته 24.82%،بينما لبايكورام 18.9% ,13.9% لاترازين خلال 0.5 h . ان عملية إلامتزازهي ظاهرة معقدة تشمل أنواع مختلفة للمواقع الأمتزازية مع طاقات سطحية مختلفة . اما البيانات من تجربة إمتزازية الدفع فقد تطابقت مع نماذج الخطي ،فرندليك و لانكمور التي حصلنا بموجبها على معامل الإمتزازية الخطية (Kd) وحساب كل من Kd, Kf, Kl, n, Cm. وإن قيم القراءات لأمتزاز كل من اترازين ، بايكلورام قد تطابقت بصورة جيدة مع موديل فرندلك، وقيم عامل السعة، Kf له رتبة S5> S1> S8> S6> S7> S3> S4 >S2و قيم Kf لبايكلورام S6> S4> S7> S3> S2> S1> S8 >S5. ان القيم المختلفة لقيمKl التي تم الحصول عليها تميزت بأن البيانات الامتزازية لبروبانيل منسجمة تماما مع صيغة لانكماير مع بلوغ عامل التراجع (الارتداد) 0.9603 ≤ R2 اما قيم Kl للبروبانيل كانت حسب النسق الاتي S5> S1 > S3 > S6> S8> S2> S4> S7 التي كما يبدو متطابقة جيدا مع المادة العضوية و نسبة الطين للتراب. كذلك قيس معدل التركيز للإبتزازية لمبيد بايكلورام حيث قيست بإستعمال قانون السرعة للمرتبة الأولى .