Assessment of Effectiveness of Crops Residue in Reducing Atrazine Leaching through the soil

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Abstract- In **this paper the prediction of Atrazine leaching through the amended soil is presented. The reason for selection of this pesticide is that it has been widely used in many states including Bihar. The soil was collected from Patna District of Bihar, India. The various properties of collected soil were analyzed in laboratory whereas, the properties of amended soil were taken from literature. The organic content of original soil obtained was 1.52 %. The soil was modified with the residue of rice straw and wheat straw having organic content 25.0 % for each case. The HYDRUS-1 D model was used to predict the leaching behavior of atrazine through the soil. The input parameters to the model were selected in such a way it simulates the field condition. In the model study, soil column depth was taken as 60 cm. The output of the model showed that the leaching of the pesticide is more in un-amendment soil as compared to amended soil. The percentage reduction in leaching as compared to the unamended soil was found as 39.0% with rice straw and 24.0 % with wheat straw. The results show that, the rice crop residue is more effective in preventing leaching phenomenon as compared to wheat crop residue. This study suggested that, the utilization of crop residue within the field can lead to preventing the leaching of pesticide. Further by using the crop residue within agriculture filed will enhance the organic content of soil and enhance the safe disposal of crop residue.**

Keywords: Atrazine, Leaching, Soil, Crop residue, HYDRUS

I INTRODUCTION

As per Environmental Protection Agency (EPA), pesticides refer to the chemicals or biological substances that are used to kill or retard the growth of pests, including weeds or other unwanted organisms. It is frequently used to eliminate or control a variety of pests which have potential to damage crops and livestock and thus safeguard the desired crop.

The use of pesticide led to a revolution in the primary sector of the economy and food security has also been ensured to rapidly growing population, apart from increasing yield of crops the quality of food crops has also been improved. Consumption of pesticides in 2001-2002 was 47.02 thousand tones, and in the 2017-2018 were 58.16 thousand tones [1]. The pesticide is extensively used in agricultural sector worldwide in order to maximize profit and it is estimated that near about 3 billion kg pesticides are used every year [2]. Several Diseases are under control like malaria and thus millions of lives have been saved or enhanced with the use of pesticides such as DDT [3]. On the other part it has caused severe threat to the environment. With the continuous use of similar type of pesticide, Pest develop immunity against that pesticide as it is stimuli against the external reaction and in long term it costs to the environment. As the data suggest 0.1% of pesticide application targets the pest rest 99.9% remain and enters in environment and contaminates the ground water [4]. The Pesticide consists of both active ingredient and inert ingredient. Most of the time inert material causes the yield to increase but sometimes it has severe ill effect on the other non-targeted organisms which remains unaccounted, and comes to account when something miss happening occurs in large scale. There are a considerable number of pesticides and their isomers, that reach the groundwater and that there is presence of pesticides in the groundwater indicated that leaching of these pesticides occur when the agricultural fields are irrigated or receive natural precipitation.

In India the share of pesticide application for only paddy crops accounts to 20%, the wheat contributes to 4%, vegetables 9% and other plantation crop consumes 7% [1]. India ranks 12th in the world for application of pesticides and is the largest producer of pesticides in Asia [4].

The application of organic amendments (OA) in the form of manure, crop residues, compost or sludge is a common agricultural practice to improve soil fertility. Organic matter increases sorption capacity of soil, which may decrease the downward movement and mobility of pesticides within soil profile [5,6,7]. Hydrophobic compounds are more likely to be adsorbed in the soil than polar pesticides [8]. The soil organic matter contributes to the enhancement of active humified components, such as humic acid and fulvic acid [9]. which also acts as adsorbents for pesticides [10] It is also reported in literature [11] found that soil amended with two commercial humic amendments (liquid LF and solid SF) from olive-mill wastes, solid urban waste and sewage sludge sorbed simazine and 2,4-D. It is reported that, addition of composted sheep manure and spent coffee grounds as soil amendments significantly reduced the movement of the eight pesticides used for pepper protection on a clay loam soil with 0.22% organic matter content [12].

II. MATERIAL AND METHODS

2.1 Materials used-

The Atrazine pesticides was used for this study. The molecular formula and molecular weight of atrazine is C8H14ClN5 and 215.7 grams respectively. The water solubility ranges from 35 mg/L at temperature range of 20 ºC. The water partitioning coefficient K_{ow} lies in the range of $10^{2.34}$ to $10^{2.80}$ at temperature 25ºC. The existence of atrazine in the soil depends upon many factors such as pH, moisture content, temperature and microbiological activity. The half-life period in soil ranges from 66 days [13].

The soil was collected from the top 15 cm surface of open field near Phulwarisharif in Patna region (India) located at latitude 25° 35′ 57″N, longitude 85° 4′ 2″ E. After collection the soil sample was dried in air, pulverised and sieved using sieve size of 2.36 mm. Soil testing were performed under the guidelines of GOI Methods Manual, Soil Testing in India, [14]. All the required parameters were analysed according to the standard method for the examination of water and wastewater [15]. The pH and electrical conductivity (EC) were determined in soil/deionised water suspension (1/2, w/v) and soil texture classification was determined using the bouyoucos hydrometer method. The average characteristics of the soil are presented in Table 1. The organic content of the original soil was measured using gravimetric method. The pulverized soil sample was heated at 60 ℃ for 24 hrs. and weighed and after noting down the weight it was burned in muffle furnace at a temperature of 550℃ for 2 hrs. The bulk density was 1.34 gm cm^{-3} for unamended soil and 1.47 gm cm^{-3} for amended soil.

Table 1- Average characteristics of collected soil used for the study

Parameters	**Values (Mean ± STD)**
Organic content	1.52±0.3 %
Electrical conductivity	0.27±0.04 µS/cm
pH	7.8 ± 0.33
Soil Texture	53% sand, 19% silt and 28% clay
Bulk Density (gm/cm^3)	1.34± 0.23

The organic content of soil is a parameter that influences the movement of solute or chemical transport in the soil. Therefore, in this study, the crop residue selected for increasing organic content of soil are rice straw and wheat straw. The value of organic content of amended soil was taken from literature [16] . The organic content of soil was increased to 25% with the help of rice straw and wheat straw residue.

2.2 Soil Column definition

The soil column is taken 60 cm, the soil profile is discretised into 101 nodes and 100 linear elements each element of same size, material 1 and material 2 are defining unamended soil and amended soil. The time weighing scheme is controlled by Crank-Nicholson scheme and time step is 0.001-day, space weighing scheme is controlled by Galerkin Finite Elements.

2.3 Input data for the model used-

In the model HYDRUS-1D, the material (soil profile) is defined as of single layer of thickness 60cm in graphical editor because most of the plant uptake is from this region only. The first order kinetic non-equilibrium linear adsorption model is chosen. As in most of the soil longitudinal and lateral dispersion are same but contamination of groundwater due to leaching of pesticides requires more attention to the downward flow of solute, hence in this study longitudinal downward flow is assumed. The flux is to be maintained at -0.5 cm/day. Upper boundary condition was concentration in 1.5×10^{-5} gm/cm^2. The first order rate constant for atrazine is 0.024/day. And the dispersivity for the soil type was assumed 5.6 cm. The adsorption coefficient (K_{OC}), is 100 and water partitioning coefficient (K_{ow}) used for the model is 2.7. The above parameter is pre-processed as input and out is post processed from the model.

2.4 Numerical simulation-

To assess the effectiveness of amendments to the soil the simulation was run for single porosity and one-site sorption model. In this study, the Material 1 is defining as the unamended soil type and the material 2 is defining as amended soil depth. For unamended soil type only material 1 is to be defined when input and for amended soil type both materials are to be defined. Material 1 here, up to a depth of 10. The 20 cm is amended with organic matter and this amended portion is material 2, the bulk density was reduced and K_d value was increased. Time duration of thirty days is defined for the simulation. For both the soil type, the upper boundary condition was taken as concentration boundary condition to be input liquid phase concentration of solute (pesticide = 0.0008 mg/cm^3) and the lower boundary condition was zero concentration gradient. The K_d value for unamended soil and amended soil was taken as 0.0003 cm^3/gm and 0.006 cm^3/gm respectively.

III. RESULTS AND DISCUSSION

As per literature, the recommended dosages of Atrazine application in the field is 1.25-2.0 kg/ha [17, 18]. Therefore, the field simulation was done with the dose of 1.5 kg/ ha i.e. equivalent to 1.5×10^{-5} gm/cc^2. The simulation study was done in soil column of 100 cm diameter for the leaching concentration at 60 cm depth of soil after 30 days of application. The output from the HYDRUS -1D model study for the unamended soil has been depicted in the Figure 1. The bottom concentration of leachate was 0.00000760 gm/cc at the depth of 60 cm after 30 days. Similar types of results obtained elsewhere [19].

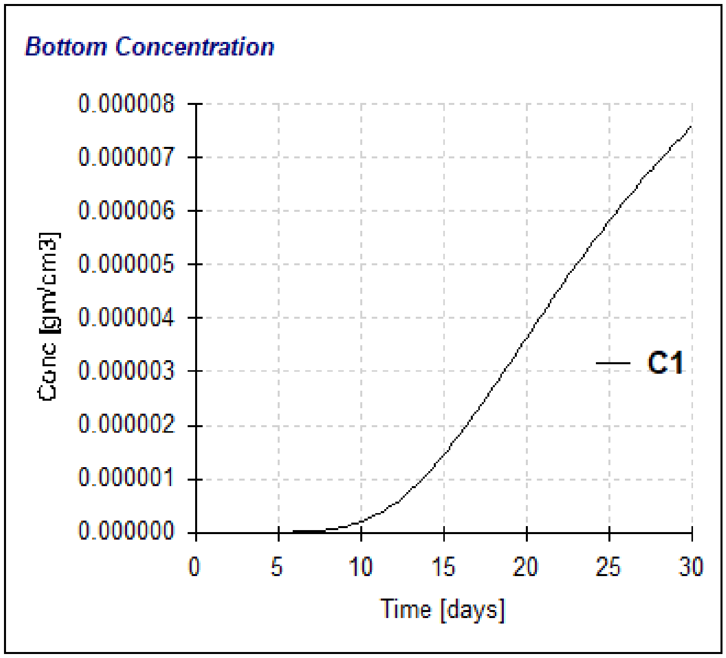

Figure 1. Bottom concentration of leachate for without amendment of soil.

The model was also operated for rice straw residue amended soil. The organic content of the amended soil was taken as 25.0 % and the output as the bottom concentration versus time in days was obtained as graph which was similar as an unamended soil hence not shown here. The model results show that the concentration of leachate was 0.00000464 gm/cc at the depth of 60 cm after 30 days. Similarly, the soil amended with wheat straw increases the soil inorganic content to 25.0% and the corresponding output as bottom concentration versus time in days was obtained. The concentration of leachate was 0.00000577 gm/cc at the depth of 60 cm after 30 days. The output of all the three cases were plotted in single graph (Figure2) showing the comparable results.

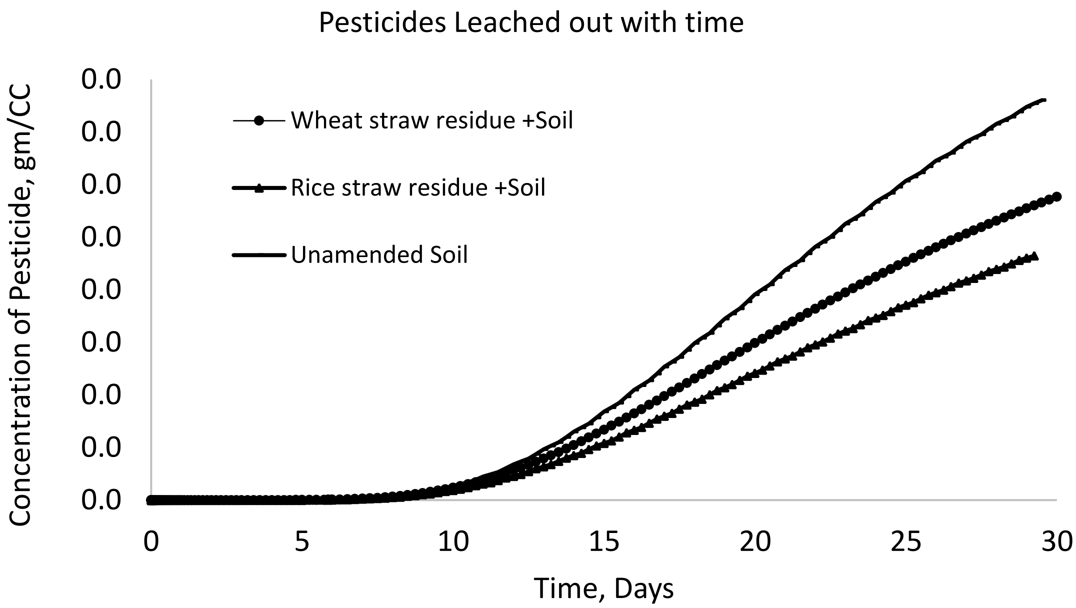

Figure 2. Bottom concentration of Leachate with Wheat straw amendment.

IV.CONCLUSION

The results of HYDRUS- 1D model reflected that, with the use of crop residue as organic amendment there was significant reduction in leaching of pesticides. The organic content of soil was increased up to 25.0 % with rice straw, and wheat straw. As compared with unamended soil, the corresponding percentage reduction in leaching through rice straw amended soil and wheat straw amended soil were found as 39.0 %, 24.0 % respectively. This gives a conclusion that rice straw is more effective in controlling leaching behaviour of Atrazine pesticide followed by wheat straws. More or less residue of the crop used has controlled the leaching through the soil used. Nowadays the stubble burning is also creating the nuisance of air pollution thus the utilization of crop residue can lead to safeguard the groundwater from contamination due to leaching of pesticide as well as the safe disposal of agricultural residue which can lead to cleaner and safer environment.

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