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Research article

Absorption and Adsorption of Trace Elements of Septic Tank Effluent into Commercial Fertilizer of Peat

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Abstract

Peat media are nowadays prepared for commercial fertilizer from natural wastes like wastewater sludge, wood chips etc. They are mostly organic and have more or less standards for commercialization. They are also used as a soil enricher and soil amender. Peat media are known to have a good moisture containing property along with a good capacity to retain chemicals from water seeping through it. Consequently, it has a good potential for refining treated wastewater effluent when the effluent passes through the media. Septic tanks are used in individual sites for the primary treatment of small flows. The effluent is often used for plant irrigation specifically in the water stressed areas of the world. Plant fields are often prepared by mixing peat with soil, particularly in sandy soil areas of deserts and oases.
This paper contains the results of absorption and adsorption tests performed utilizing septic tank effluent on commercial peat media in columns. Selected chemical species of Mg, ZN, Fe, PO_4 and NO_3 were monitored. Results showed that on an average scale Mg, Zn, Fe, PO_4 and NO_3 are retained in peat columns at 74.53 x 10^{-6} g/gram of peat, 0.61 x 10^{-6} g/gram of peat, 0,074 x 10^{-6} g/gram of peat, 37.26 x 10^{-6} g/gram of peat and 6.09 x 10^{-6} g/gram of peat, respectively.

Keywords: Column tests, peat bio-filter, selected chemicals, treated wastewater, isotherm

1. Introduction

Peat materials are common natural media and are widely used as a soil enricher and a nutrient source for plants. It also has an excellent property of water retention for plant use. Due these properties it is often used as a fertilizer for soil amendments and plant growth in landscaping, nursery, greenhouses and agricultural fields.
Peat fertilizer (horticultural media) is known to absorb and adsorb chemical elements when in contact with polluted water. The utilization of peat materials for removing objectionable trace pollutants from treated

wastewater might be an innovative process when peat is solely used as absorbing media or mixed with agricultural soil in situ.
Peat bio-filter treatment of domestic wastewater at individual households is very common [1, 2]. Its uses include being a replacement of traditional household septic tanks and in many cases, as a retrofit system following an existing primary treatment system of septic tanks. In the latter type of retrofit systems, the reduction in biochemical oxygen demand (BOD) was found to range from 80 to 100% when inflow BOD was as high as 623 mg/l [3]. The results also showed total suspended solids (TSS) reduction ranging between 85 to 91% and nitrogen reduction around 35%.
Recently, a study was carried out focusing on peat adsorption and absorption of chemical species prevailing in domestic septic tank effluent. The adsorption and absorption tests were performed utilizing peat columns for selected chemicals of NO_3 (Nitrate), PO_4 (Phosphate), Fe (Iron), Zn (Zinc) and Mg (Magnesium).

2. Materials and Methods

2.1 Adsorption and Absorption Media

When a chemical is present in water that is seeping through a soil media, the chemical is expected to be partly adsorbed and absorbed in the media. However, the natural septic tank effluent contains multiple species of chemicals that are supposed to be absorbed and absorbed simultaneously in the media. Therefore, the absorption and adsorption tests performed in this study measured the exhaustion status of a target chemical through the absorption and adsorption process in the selected media when other species of chemicals are also present in the media-liquid matrix.
The media that was used for the absorption and adsorption media was commercial peat soil that is usually used as a fertilizer. They are used as a soil enricher, plant nutrient supplier and plant bed, and have a high water retention capacity. The main chemical contents of the peat media is shown in Table 1.

Table 1. Main chemical contents of peat media.

Chemical and Materials	**Percentage by Weight**
Organic materials	45.00
P_2O_2	1.01
Mn	0.50
Zn	0.71
Cu	0.15
N	2.30
K	0.63
Mg	2.70
Fe	1.10

2.2 Materials

Peat holding columns were made of chemically non-reactive plexi-glass materials. A spray nozzle was used to spray water on top of the peat media. Plexi-glass tubes fitted at the bottom of the tank were used to drain out the seeped through (treated) water.
The inflow was from a domestic septic tank effluent line. This effluent gets primary treatment in an anaerobic septic tank. Before its application to the media, the effluent was oxygenated by bubbling natural air through the effluent for nearly 10 to 15 h. Figure 1 shows the schematic of the assembled systems of the peat columns.
Multiple columns were used to operate more than one test simultaneously. On an average, 12 h of aeration was provided to freshen the septic tank effluent in the aeration tank. The storage tank contained enough liquid capacity to provide for 24 h inflow to the operating columns. The inflow rate into the columns was on an average 31.44 l each day. Square columns were made of plexi-glass sheets. The dimensions of the columns appear in figure (1). The columns were 12 cm x 12 cm square of variable length. However, the peat height of 1m and the height of 45 cm sand-support under the peat were constant for all columns. Peat media of 10.6 kg was used for each column. The columns stood vertical to facilitate gravitational flow of liquid through the media.

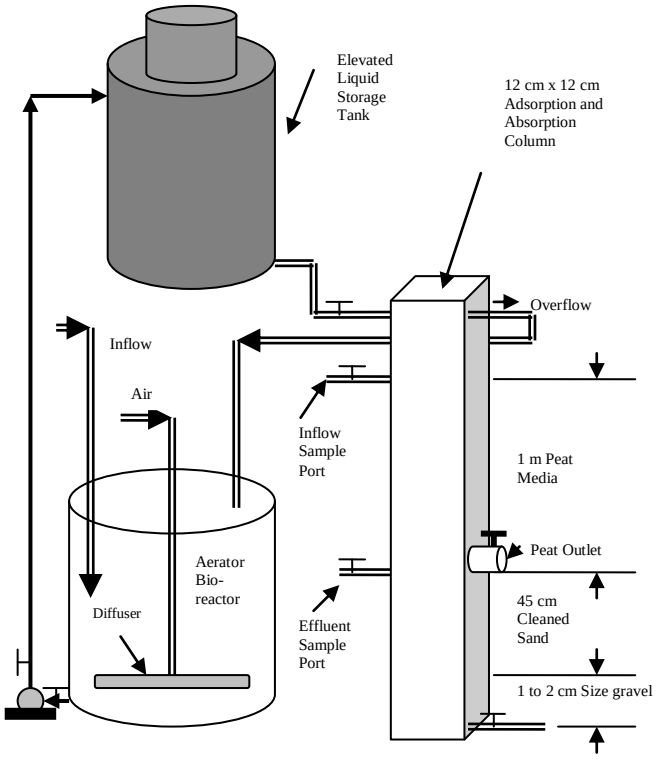

Figure 1. Schematic of peat adsorption and absorption system

All laboratory tests were performed in the Sulaibiya Wastewater Laboratory at the Kuwait Institute for Scientific Research (KISR). The laboratory tests for chemical determination were performed according to the standard methods [4].

3. Results

In a test column, the inflow is introduced at the top of the column and the effluent exits at the bottom of the column media. For each tested chemical specie, several isotherms (NO_3 = 9, PO_4 = 5, Fe = 5, Zn = 5 and Mg = 6) were generated for the adsorption and absorption of chemical through the peat media used in the column. A breaking point in a chemical isotherm is defined in terms of the time and the combined flow of that passes through the column until the outflow concentration of the chemical is more or less the same as that of inflow, as shown in figure (2).

The results of the column tests for magnesium, zinc, iron, total phosphate and nitrate-nitrogen appear in Tables 2, 3, 4, 5 and 6, respectively. These tables show the days necessary for an isotherm to be fully developed (starting to break point), the inflow concentration, the outflow concentration at first appearance of the flow at column bottom, the average of the first outflow concentration and the concentration in the outflow at the break point of the column (outflow concentration is more or less the same as the inflow concentration), and the amount retained in the column per unit-flow for each isotherm. Each row in a table shows the data for an isotherm. The inflow rate was on an average 31.44 l/d, and it remained the same for all the tests.

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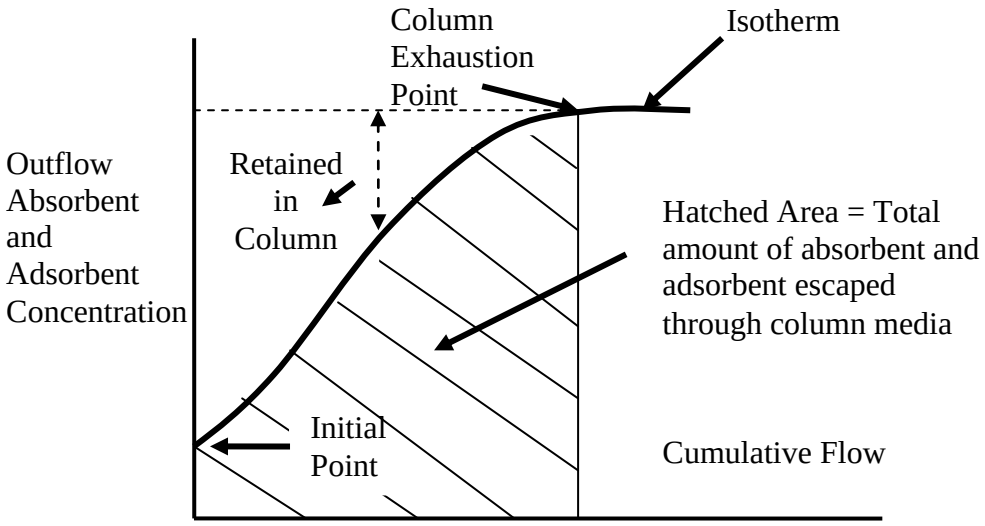

Figure 2: Typical exhaustion isotherm

4. Data Analysis and Discussion

Residual pollution in septic tank effluent very often ends up in the soil beds either through planned leach (leach bed) or natural soil. Natural peat contact with such effluent might take place when peat dumps are used for further refining the effluent while the effluent water is passed through the peat-only media. Peat might also come in contact with septic tank effluent when it is used as a soil enricher and fertilizer for plant irrigation. In the latter case, peat is mixed with the top soil within a plant root zone.

Table 2. Adsorption and absorption of magnesium (Mg) in a peat column

Magnesium (Mg)							
Test No.	Total Flow to Break point (m^3)	Average Concentration in Inflow (g/m^3)	Outflow Concentration at Beginning of Test (g/m^3)	Average of Previous Two Columns (g/m^3)	Retained in Column per unit volume (g/m^3)	Total Mass Retained in Column (g)	Adsorbed and Absorbed in Column (10^{-6}g/g of media)
1	0.0629	46.08	23.19	34.635	11.445	0.72	67.92
2	0.0629	46.47	22.62	34.545	11.925	0.75	70.75
3	0.0629	43.35	12.07	27.710	15.640	0.98	92.45
4	0.0629	44.02	19.95	31.985	12.000	0.75	70.75
5	0.0629	41.29	20.19	30.740	10.550	0.66	62.26
6	0.0629	41.98	13.79	27.885	14.000	0.88	83.02

Table 3. Adsorption and absorption of zinc (Zn) in a peat column

Zinc (Zn)							
Test No.	Total Flow to Break point (m^3)	Average Concentration in Inflow (g/m^3)	Outflow Concentration at Beginning of Test (g/m^3)	Average of Previous Two Columns (g/m^3)	Retained in Column per unit volume (g/m^3)	Total Mass Retained in Column (g)	Adsorbed and Absorbed in Column (10^{-6}g/g of media)
1	0.126	0.2727	0.1839	0.22830	0.04440	0.0056	0.53
2	0.126	0.3352	0.2340	0.28460	0.05060	0.0064	0.60
3	0.157	0.2751	0.2030	0.23905	0.03605	0.0057	0.54
4	0.189	0.2178	0.1293	0.17355	0.04425	0.0083	0.78
5	0.157	0.2069	0.1228	0.16485	0.04205	0.0066	0.62

Table 4. Adsorption and absorption of iron (Fe) in a peat column

Iron (Fe)							
Test No.	Total Flow to Break point (m^3)	Average Concentration in Inflow (g/m^3)	Outflow Concentration at Beginning of test (g/m^3)	Average of Previous Two Columns (g/m^3)	Retained in Column per unit volume (g/m^3)	Total Mass Retained in Column (g)	Adsorbed and Absorbed in Column (10^{-6}g/g of media)
1	0.094	0.0228	0.000	0.0114	0.01140	0.00110	0.1040
2	0.126	0.0100	0.000	0.0050	0.00500	0.00063	0.0594
3	0.031	0.0389	0.000	0.01945	0.01945	0.00061	0.0580
4	0.062	0.0290	0.003	0.0160	0.01300	0.00080	0.0755
5	0.126	0.0248	0.001	0.0129	0.01190	0.00150	0.1415

Table 5. Adsorption and absorption of 'PO4' in a peat column

Total Phosphate as PO_4							
Test No.	Total Flow to Break point (m^3)	Average Concentration in Inflow (g/m^3)	Outflow Concentration at Beginning of test (g/m^3)	Average of Previous Two Columns (g/m^3)	Retained in Column per unit volume (g/m^3)	Total Mass Retained in Column (g)	Adsorbed and Absorbed in Column (10^{-6}g/g of media)

1	0.157	12.1	6.68	9.390	2.700	0.424	41.00
2	0.063	16.03	5.30	10.665	5.360	0.337	31.79
3	0.189	14.00	11.15	12.575	1.425	0.269	25.38
4	0.189	12.90	8.10	10.500	2.400	0.453	42.74
5	0.063	12.90	11.37	12.135	0.765	0.481	45.38

Table 6. Adsorption and Absorption of Nitrate in Peat Column

Nitrate-Nitrogen							
Test No.	Total Flow to Break point (m^3)	Average Concentration in Inflow (g/m^3)	Outflow Concentration at Beginning of test (g/m^3)	Average of Previous Two Columns (g/m^3)	Retained in Column per unit volume (g/m^3)	Total Mass Retained in Column (g)	Adsorbed and Absorbed in Column (10^{-6}g/g of media)
1	0.157	3.30	2.500	2.9000	0.400	0.0628	5.92
2	0.189	1.00	0.200	0.6000	0.400	0.0756	7.13
3	0.189	0.70	0.050	0.3750	0.325	0.0614	5.79
4	0.157	0.75	0.000	0.3750	0.375	0.0589	5.56
5	0.063	2.25	0.225	1.2375	1.012	0.0638	6.02
6	0.094	3.50	2.050	2.7750	0.725	0.0682	6.43
7	0.063	4.10	1.850	2.9750	1.125	0.0709	6.69
8	0.063	2.05	0.130	1.0900	0.960	0.0605	5.71
9	0.094	1.25	0.001	0.6255	0.624	0.0587	5.54

It is of interest to know the extent of adsorption and absorption of certain residual pollutants in septic tank effluent through peat media. The limited study focused mainly on fertilizer components like phosphorus and nitrogen, and metallic ions of magnesium, zinc and iron. The absorption and adsorption that was monitored was a gross combination of two phenomena of the adsorption and absorption of a selected chemical when they naturally occur simultaneously in the presence of all potential absorbable and adsorbable elements.
The results of the limited tests in terms of the average, the standard deviation, the maximum and minimum absorption and adsorption of Mg, ZN, Fe, PO_4, and NO_3 appear Table 7. Significant scatterings in absorption/adsorption were observed with Mg and PO_4. Mg and Fe are more retained in the media when compared to that of other measured species in terms of relative input concentrations (Tables 2, 3, 4, 5 and 6).

5. BOD_5 Reduction in Peat Column

A mixed action of adsorption, absorption, particle entrapment, anaerobic bio-activity is expected to take place in the reduction of BOD_5 in the peat media. Hence, the reduction should not be exclusively accounted for adsorption and absorption in the case of BOD removal in the column. A distinct and significant reduction of

BOD_5 was observed only in four cases out of 30 column tests. The average and the maximum and minimum reductions in BOD_5 were found to be 27, 51 and 8 percent, respectively (Table 8) in an average liquid detention of 11 h in the column.

Table 7. Adsorption and Absorption of Selected Chemicals in Peat Media

Chemical Element	**Average x 10^{-6} g/g**	**Maximum x 10^{-6} g/g**	**Minimum x 10^{-6} g/g**	**Standard Deviation x 10^{-6} g/g**
Mg	74.53	92.4500	62.260	11.060
Zn	0.610	0.7800	0.530	0.100
Fe	0.088	0.1415	0.058	0.035
PO_4	37.260	45.3800	25.380	8.380
NO_3	6.090	7.1300	5.540	0.549

Table 8. BOD_5 reduction

Test Case No.	**BOD_5 in Inflow (mg/l)**	**BOD_5 in Outflow (mg/l)**	**Percentage Reduction of BOD_5 in 10 kg of Peat Media**
1	70.0	34.00	51
2	70.5	45.00	36
3	156.0	135.50	13
4	102.0	93.75	08
Liquid Detention time in column = 11 hr Peat media in column = 10.6 kg BOD_5= biochemical oxygen demand for five days			

6. Conclusion

Peat fertilizer is frequently used in agricultural fields, and it is used as an admixture to soil in plant root zones, which is extended down to a maximum of one meter from the soil surface for most seasonal crops and plants. In water stressed countries, treated wastewater effluent, specifically septic tank effluent, is often used on-site for irrigation. Among the residual pollutants in the effluent, magnesium, zinc, iron, total phosphate and nitrate nitrogen are very common. Based on the results of the column tests on absorption and adsorption through peat media, the following conclusions might be drawn:

1. The results of adsorption and absorption tests of residual chemicals in septic tank effluent through peat media for several selected chemical elements and radicals (Mg, Zn, Fe, PO_4 and NO_3) show significant retention of these chemicals in peat media.
2. In the media exhaustion of adsorption and absorption, the average magnesium, zinc and iron retained in peat media, made of peat only, were 73.99 x 10^{-6} g/ g peat, 0.56 x 10^{-6} g/ g peat and 0.088 x 10^{-6} g/ g peat, respectively.
3. In the media exhaustion of adsorption and absorption, the average total phosphate (PO_4) and nitrate nitrogen (NO_3) retained in the media, made of peat only, were 36.26 x 10^{-6} g/ g peat, and 6.45 x 10^{-6} g/ g peat, respectively.
4. On an average, about 27 % of residual BOD_5 in septic tank effluent is expected to be further reduced by using peat media.

7. Acknowledgment

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8. References

[1] Austin W., Septic Tank and Peat Filter. Onsite Treatment (Pretreatment) System Fact Sheet, City of Austin, Texas, USA. http://www.ci.austin. tx.us / wri/treat14.htm. 31st December, 2010.

[2] Patterson, R.A., 1999. Peat treatment of septic tank effluent. Proceedings of the On-Site 99 Conference: Making On-Site Wastewater Systems Work. University of New England, Armidale. Lanfax Laboratories, Armidale, 13-15 July 1999, Pp 273-281.

[3] Barnstable Country Department of Health, Wastewater System Information, Barnstable, USA. www.barnstablecountyhealth.org /ia-systems/information-center/6th July 2010.

[4] American Public Health Association (APHA), American Water Works Association (AWWA) and Water Environment Federation (WEF). Standard Methods for the Examination of Water and Wastewater. 22nd Edition, USA 2012.