Title: Evaluating the Reuse of Swine Lagoon Effluent and Reclaimed Municipal Water for Agricultural Production

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Congressional District: Oklahoma 3rd

Focus Category: WQL

Descriptors: Swine effluent, treated wastewater, irrigation, alternative water sources, nutrient buildup and losses, soil health, water quality, crop production

Students: (Include number of students supported by the project during the project period in the table below.)

Student Status	Number	Disciplines
Undergraduate		
M.S.		
Ph.D.	0.2	Soil Science
Post Doc		
Total		

Principal Investigators:

Hailin Zhang, Regents Professor, Plant and Soil Sciences, OSU

Publications: None

Problem and Research Objectives:

Significant amount of water in Oklahoma is used for crop irrigation. Water shortage in Oklahoma and the Southern Great Plains has become a major limitation for crop production and other uses, which will have a major impact on local economy. Therefore, alternative sources of irrigation water need to be explored. Treated municipal wastewater (TWW) is one of the most readily available alternative water sources, although infrastructures to use TWW for crop irrigation are lacking in most places and public acceptance is probably low because of the lack of field evaluations in the state. Currently, most TWW in the state is directly discharged to steams and rivers rather than recycled for crop production. Treated swine lagoon effluent is also available in west Oklahoma and other regions. Although swine effluent has been used to irrigate crops, more water use efficient application techniques need to be evaluated and promoted.

The objectives of this project were to 1.) evaluate the impact of continuous subsurface drip irrigation of swine effluent on salt and nutrient buildup and movement in soils; 2.) establish an environmental and agricultural baseline in a newly constructed treated municipal wastewater recycling site.

Methodology:

For the first objective, grid soil samples (grid size was about 2 acres) up to 1 m deep was collected the field where the subsurface drip irrigation of swine effluent was installed. The profile samples were separated into 0-6”, 6-12”, 12-24” and 24-36” segments. Soil samples were analyzed for pH, plant available N, P, K and electrical conductivity (EC). Five pairs of lysimeters were installed at selected locations at 2 and 4 feet deep to monitor nitrate leaching potential to groundwater but no leachate was collected due draught during the study period. Nutrient and EC maps were generated using GIS software and plotted vertically with soil depth. Effluent application quantity and timing were obtained to calculate the nutrient input. The conditions and effectiveness of the irrigation tape after 11 years in operation was evaluated as well.

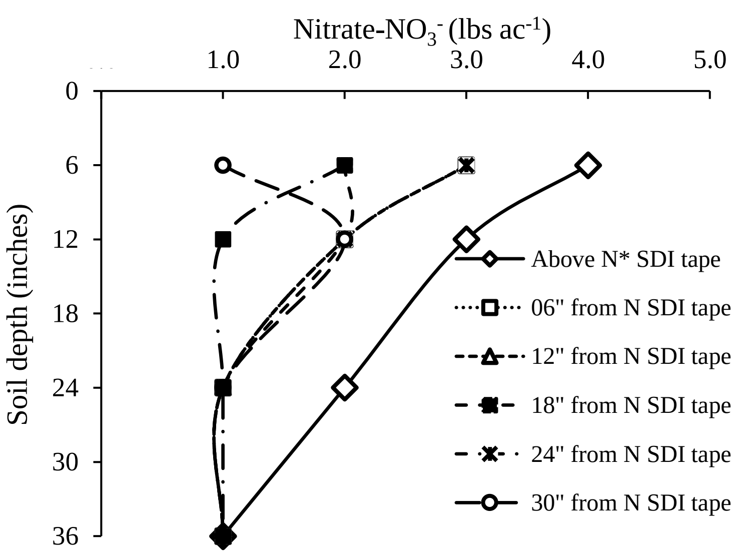
For the second objective, similar soil and plant health monitoring was conducted at the South Central Research Station in Chickasha where the reclaimed municipal wastewater was used for irrigation. Soil Samples were collected to 1 m deep at the beginning of the project. Treated wastewater was analyzed for irrigation water quality several times. Groundwater monitoring wells were installed at the beginning of the project at 6 strategic locations. Water samples from the monitoring well were collected and analyzed for common nutrients and salts.

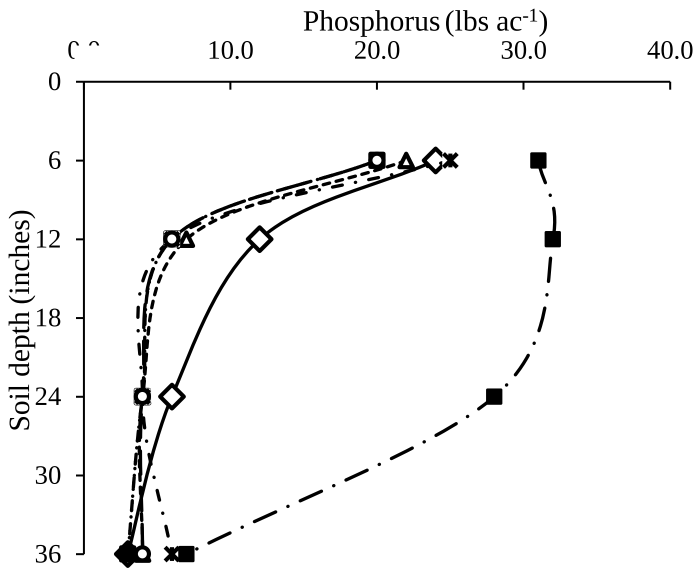
Principal Findings and Significance:

1. Swine lagoon effluent is a good source of water and plant nutrients. It should be land applied when possible.

Figure 1. Bermudagrass in the field with subsurface drip irrigation system to distribute anaerobically digested lagoon effluent. The strips of grass reflect the orientation of drip tapes. The effluent supplied nutrients and water and resulted in good growth.

2. Subsurface drip irrigation is an efficient method of delivery the effluent to the parenial bermudagrass pasture. At the rates applied for 12 years, there was no evidence of nutrient and salt buildup in the soil, and movement to the groundwater. The drip tape was in good condition 12 years since installation and similar evaluations should be conducted about 5 years in the future.





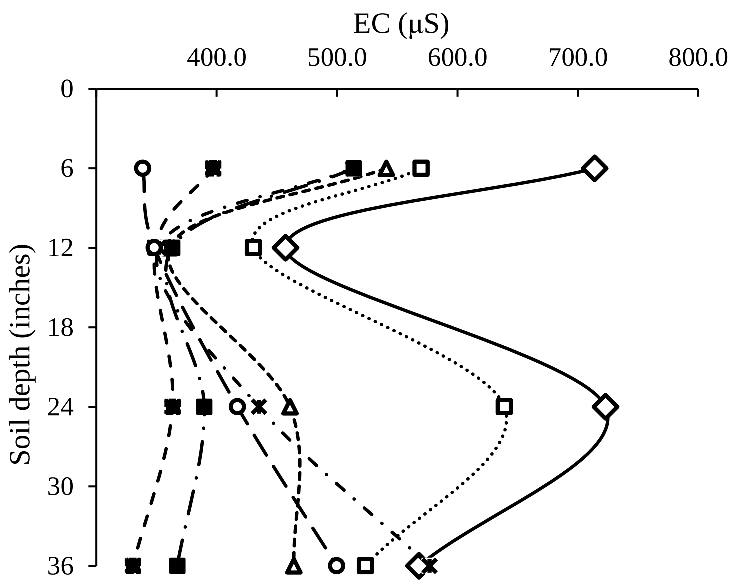


Figure 2. Representative nitrate-N, soil test P and EC distribution in soil profile between 2 drip tapes. All 3 analytes are typical of most agricultural soils. The soil test P is still below the 100% sufficiency level in Oklahoma.

3. The quality of the treated manuciple wastewater from Chickasha is considered acceptable irrigation water for most crops based on the analytes tested. It does contain some nitrogen and other beneficial nutrients. Therefore, it is recommended to give credits to those nutrients when deciding the amount of fertilizers to be applied to avoid over application.

Table 1. The quality of the treated municipal wastewater used for irrigation in Chickasha, OK.

Sampling dates	pH	EC	TDS	Nitrate-N	ICP-P	B	Sulfate	SAR	Na%
		uS/cm	---------------------ppm---------------------------						
3/15/2016*	7.8	1218	824	11.6	1.12	0.3	183	1.8	32
5/15/2016	8.0	1210	823	11.3	1.12	0.3	182	1.9	32
3/16/2017	8.4	1113	735	18.1	1.64	0.3	159	2.2	38

*sampled at the pump by the treatment plant. The rest of the samples were collected at the discharge point.

4. The baseline of soil properties in the 2 fields designed to receive treated wastewater has been established, and will serve as a comparison for future evaluations.

Table 2. Soil samples (0-6”) from the field with center pivot irrigation systems in Chickasha.

Grid Number	pH	NO_3-N lbs A^{-1}	K	P	Ca	Mg	SO_4-S lbs A^{-1}	Cu	Fe	Zn	B	OM %	EC (µS)
			….Mehlich-3 (lbs A^{-1})…					..DTPA-sorbitol (ppm)..					
1	6.2	50	311	49	3141	1072	11.5	0.6	16.5	0.5	0.15	1.93	1356
2	6.5	23	467	52	3875	1599	12.6	0.8	17.5	0.4	0.19	2.42	1062
3	5.8	14	284	59	2507	1017	11.4	0.7	20	0.3	0.14	1.94	520
4	5.9	54	471	62	3503	1414	10.7	0.9	36.4	0.3	0.16	2.31	1245
5	6.3	20	521	75	4122	1718	8.8	1	34.7	0.4	0.21	2.56	900
6	6.1	36	322	45	2856	1129	10.9	0.7	18.6	0.3	0.17	2.1	924
7	6.2	8	382	28	3875	1205	12.3	0.7	17.3	0.3	0.23	2.64	738
8	6.6	6	606	30	4767	2067	12.9	1.2	29.2	0.4	0.34	2.95	681
9	6.4	3	287	26	3239	1032	9.9	0.5	12.9	0.2	0.16	2.02	513
10	6.1	6	287	26	2968	983	13.3	0.7	19.9	0.3	0.20	1.95	624
11	6.1	17	383	36	3658	1286	16.1	0.8	25.9	0.3	0.22	2.61	801
12	6.5	13	510	40	4165	1587	10.5	0.8	24.6	0.3	0.29	2.72	816

5. Six groundwater monitoring wells were installed at strategic locations and water samples were taken and analyzed. This first set of data will serve as the baseline for future references.

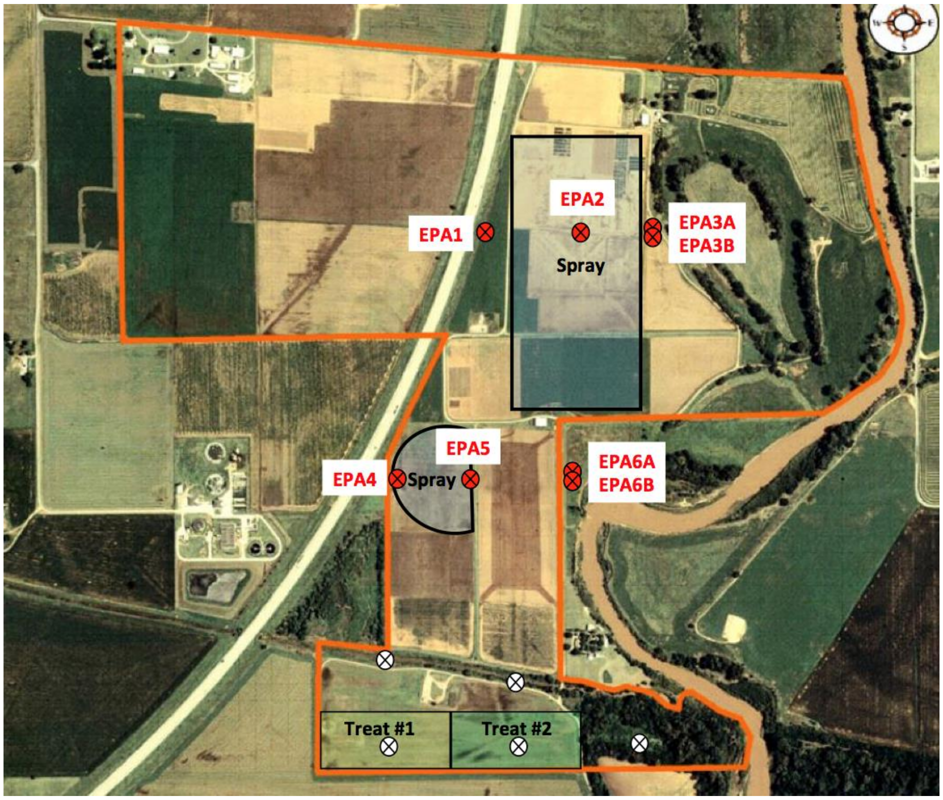


Figure 4. The locations of groundwater monitoring wells located above, inside and below the groundwater gradient under the irrigated area.

Table 3. Analysis from samples collected from the monitoring wells.

Well Number	pH	EC (µS)	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	NO_3-N (ppm)	Cl (ppm)	SO_4 (ppm)	HCO_3 (ppm)	B (ppm)	TDS (ppm)	PAR (%)	SAR (%)	EPP (%)	ESP (%)	Hardness (ppm)	Alkalinity (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	$NH_{4\text{-}N}$ (ppm)	P (ppm)
EPA1	7.6	1663	41	4.0	84	166	2.5	145	38	835	0.4	1316	0.03	0.6	3.8	< DL	892	685	0.01	< DL	0.12	0.46	0.06	0.26
EPA2	7.6	5690	1042	6.0	202	109	0.2	615	1762	626	3.1	4363	0.05	14.7	4	16.8	954	513	0.01	< DL	0.36	0.35	0.3	0.19
EPA3A	7.6	1824	102	3.0	106	151	8	82	133	927	0.8	1511	0.03	1.5	3.7	0.9	884	760	< DL	< DL	0.14	0.14	0.02	0.06
EPA3B	7.6	2600	291	3.0	107	152	4.5	253	413	821	1.2	2045	0.03	4.2	3.7	4.7	894	673	< DL	< DL	0.02	0.07	0.02	0.41
EPA4	7.7	1499	33	2.0	77	152	4.1	98	39	791	0.3	1195	0.02	0.5	3.6	< DL	819	648	< DL	< DL	< DL	0.05	0.01	0.28
EPA5	7.6	1522	82	3.0	92	127	0.2	68	134	791	0.7	1297	0.03	1.3	3.7	0.6	754	649	0.01	0.02	0.85	0.06	0.14	0.21
EPA6B	7.8	2430	335	2.0	90	120	1.1	190	446	813	1.5	1997	0.02	5.4	3.7	6.3	719	666	0.01	< DL	0.02	0.27	0.02	0.29
Ave.	7.6	2461	275	3.3	108	140	2.9	207	424	800	1.1	1961	0.03	4.0	3.7	5.9	845	656	0.01	0.02	0.25	0.20	0.08	0.24

6. This priliminary work laid a foundation for more studies on how treated wastewater affecting soil health and crop production in the future.