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# Simulating Effects of Long Term Use of Wastewater on Farmers Health Using System Dynamics Modeling (Case Study: Varamin Plain)

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**Introduction:** Agricultural activity in Varamin plain has been faced with many challenges in recent years, due to vicinity to Tehran the capital of Iran (competition for Latian dam reservoir), and competition with Tehran south network in allocation of Mamlou dam reservoir and treated wastewater of south wastewater treatment plant. Mamlou and Latian dam reservoirs, due to increase of population and industry sectors, allocated to urban utilization of Tehran. Based on national policy, the treated wastewater should be replaced with Latian dam reservoir water to supply water demand of agricultural sector. High volume transmission of wastewater to Varamin plain, will be have economical, environmental, and social effects. Several factors effect on wastewater management and success of utilization plans and any change in these factors may have various feedbacks on the other elements of wastewater use system. Hence, development of a model with capability of simulation of all factors, aspects and interactions that affect wastewater utilization is very necessary. The main objective of present study was development of water integrated model to study long-term effects of irrigation with Tehran treated wastewater, using system dynamics modeling (SD) approach.

**Materials and Methods:** Varamin Plain is one of the most important agricultural production centers of the country due to nearness to the large consumer market of Tehran and having fertile soil and knowledge of agriculture. The total agricultural irrigated land in Varamin Plain is 53486 hectares containing 17274 hectares of barley, 16926 hectares of wheat, 3866 hectares of tomato, 3521 hectares of vegetables, 3556 hectares of alfalfa, 2518 hectares of silage maize, 1771 hectares of melon, 1642 hectares of cotton, 1121 hectares of cucumber and 1291 hectares of other crops. In 2006 the irrigation requirement of the crop pattern was about 690 MCM and the actual agriculture water consumption was about 620 MCM (supplying 90 percent of the demand), 368 MCM of which was supplied through groundwater and 252 MCM was supplied by surface water. In recent years supplying water from Latyan Dam to the agriculture in Varamin Plain due to water supply of Tehran and the recent droughts has been reduced to lower than half (the average 68.8 MCM). On the other hand, shortage of surface water resources has caused an additional pressure to the groundwater resources of the Plain. Excessive groundwater withdrawal and use of brackish reused waters in the southern parts of the plain has caused the quality loss in groundwater resources, so that groundwater salinity has increased about 0.5 dS/m from the year 2000 to 2011. Obviously, by continuing the present situation, in less than two decades the groundwater resources in Varamin will be either quite destroyed or unable to be used due to inappropriate quality. Another source of surface water is allocated to the Varamin Plain is treated wastewater produced from Tehran Wastewater Treatment Plant. Utilizing the phases 1 to 4 of this treatment plant, about 80 MCM (2.5 up to 4 m3/s) of wastewater is annually transferred to Varamin Plain. According to the projections, it is assumed that wastewater will be used in near future as the most important water resource to Varamin Plain. In this study, SD was applied as the system analysis method for the Varamin wastewater management. The spatial boundary of the SD model for Varamin model was the whole Varamin area, which is 1584 km2. The historical review period was from 2001 to 2011, the simulated period was from 2011 to 2036, and the simulation time interval was one year. The most important scenarios evaluated consisted of four wastewater allocation scenarios [(i) keeping the excising condition, (ii) complete allocation of Latian dam reservoir water to Tehran domestic use, allocation of 200 MCM treated wastewater during growing season to agricultural sector and 40 MCM to artificial aquifer recharge during non-growing season starting year 2016, (iii) similar to scenario number two w/o artificial aquifer recharge and (iv) similar to scenario number two plus allocating 50 MCM starting year 2021]. Mass flow or convection method by considering surface adsorption of solute was used to survey movement and adsorption of elements in soil. Adsorption isotherms delineated and determined by field and experimental measurement.

**Results and Discussion:** The result indicated that if raw wastewater be used till 2031, Cadmium and Copeer concentration will be outstanding and will have harmful effects on farmer's health. Utilization of treated wastewater will be safe and will have not harmful effects on farmer's health by heavy metals, to about 150 future

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years. Also, simulating result showed that Nitrate concentration in groundwater will exceed from allowable limitation for potable water in all scenarios to 2031. Application of scenarios (iv) and (iii) lead to the lowest and the highest Nitrate concentration, respectively.

**Conclusion:** In this model a systems system dynamics approach was applied to understand how various factors related to operation of wastewater and water sustainability interrelate. The developed model is capable to simulation of all factors, aspects and interactions that affect wastewater utilization. Result of this study demonstrated that SD is a useful decision support tool for sustainable wastewater management. By considering severe water shortage problems in the study area, and safe utilization of treated wastewater, treated wastewater transmission of Tehran plant to Varamin Plain can help to solve water shortage problems. Increase of treated wastewater allocation lead to decrease of raw sewage and hereby decreasing hygienic harmful effects.

**Keywords**: Artificial recharge, Causal Loop Diagram, Key variable, Stocks - flows