Modeling the Extent of Virus Removal in Waste Stabilization Ponds to Support Reuse of Wastewater

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ABSTRACT

This paper enlist from the problem of wastewater pollution. The main motive of this research was of remove the virus, extent in separate waste stabilization ponds which help to reuse wastewater. Waste stabilization ponds (WSPs) are one of the most rife types of domestic wastewater treatment technologies utilized global, and global stressors such as urbanisation, population growth, global climate condition change, and water absence have growth the demand for reusing treated wastewater. The safe reuse of treated wastewater in agriculture can ease water scarcity, aid in food production, and reduce environmental degradation from the discharge of wastewater effluent to surface waters. This treatment technique is suitable for discharge to the environment or for reuse in agriculture. WSPs is depend upon the ponds and the main three different type of WSP anaerobic, facultative, and maturation ponds.

Keywords: wastewater, stabilization, WSPs, pond, efficiency, reuse, virus, treatment etc.

1. INTRODUCTION

In this paper we discuses the Waste stabilization ponds (WSPs, lagoons, ponds) techque.it is a types of wastewater treatment technologies worldwide, maximum found in rural areas, small communities, and developing communities, as well as some cities. The technique of WSP systems is given by the Latin America, New Zealand, United States and many other countries. these countries are play are major role in WSPs. this system is a very inexpensive and easy to construct, appropriate technology especially when we are compare to some mechanized wastewater treatment technologies. WSPs are the shallow engineered pond basins (approximately 1-5 m in depth) that create natural method such as gravity settling, photosynthesis, microbial metabolism, and sunlight-mediated mechanisms to reduce the concentrations of organic matters (measured as biochemical oxygen demand, BOD), total suspended solids (TSS) and pathogens in wastewater (Mara, 2004). The WSP system is mainly classified in three type of pond Anaerobic, Facultative, Maturation pond these are useful to treatment objective dissolved oxygen content. Table 1.1 summarizes key characteristics of each of these three types of WSPs. it is depend on topography, gravity may be utilized to direct the wastewater through a series of ponds. A conventional pond system configuration consists of facultative ponds followed by maturation ponds, or anaerobic ponds followed by facultative and maturation ponds. Anaerobic and facultative ponds are typically designed for biochemical oxygen demand (BOD) and total suspended solids (TSS) removal, and maturation ponds are designed for pathogen removal and further removal of BOD and TSS. Maturation ponds can produce effluent with low concentrations of BOD, TSS, and pathogens if a series of ponds is properly design.

Table 1.1: Characteristics of the principal types of waste stabilization pond

Type of WSP	Characteristics	Typical depth (m)	Hydraulic Retention time (days)	Purpose
Anaerobic	No oxygen,deep, nonaerated. Anaerobic digestion occurs in sludge layer (produces biogas).	2-5	1-7	Primary function is BOD/TSS removel (around 60%) Treat high strength wastewater. Recover biogas.
Facultative	Dissolved oxygen On top layer No oxygen on bottom layer. Combination of aerobic, Anoxic, and anaerobic processes	1.2-2.5	10-180	Moderately effiective at removing settleable solids, BOD, pathogens, fecal coliform, and ammonia
Maturation	Dissolved oxygen throughout entire depth. Aerobic processes.	1-1.5	3-15	Pathogen removel, such as pathogenic bacteris,viruses. Polishing(further BOD/TSS removel)

This is the first study that attempted to model the global extent of enteric virus and bacteriophage removal in individual waste stabilization ponds. While the removal of fecal indicator bacteria in WSPs has been well characterized, many uncertainties and knowledge gaps still remain about virus removal efficiency; which makes it difficult to estimate the viral risk associated with wastewater reuse. This system may also help for the government to work against the wastewater problem.

2. MATERIAL AND METHODS

The waste stabilization ponds are manmade depressions confined bye earthen structure.In this system the database compiled by Verbyla and Mihelcic (2015) was the primary source of data used for the study. Additional virus concentration data were sought using the same methodology as Verbyla and Mihelcic (2015) and one additional WSP was added to the initial database (Jurziket al., 2015), resulting in a total of 50 publications with virus or bacteriophage removal data from 72 WSP systems.

Figure 3.1 shows the decision making process that was followed to determine which data possessed the suitable requirements for mathematical modelling and statistical analysis and which data were determined to be outliers and thus removed from further evaluation. Several additional measures, besides those identified from the process shown in Figure3.1, were employed to determine additional outliers in the WSP database. Other publications that described virus removal in storm water ponds, aerated ponds, and laboratory scale experiments were also excluded.

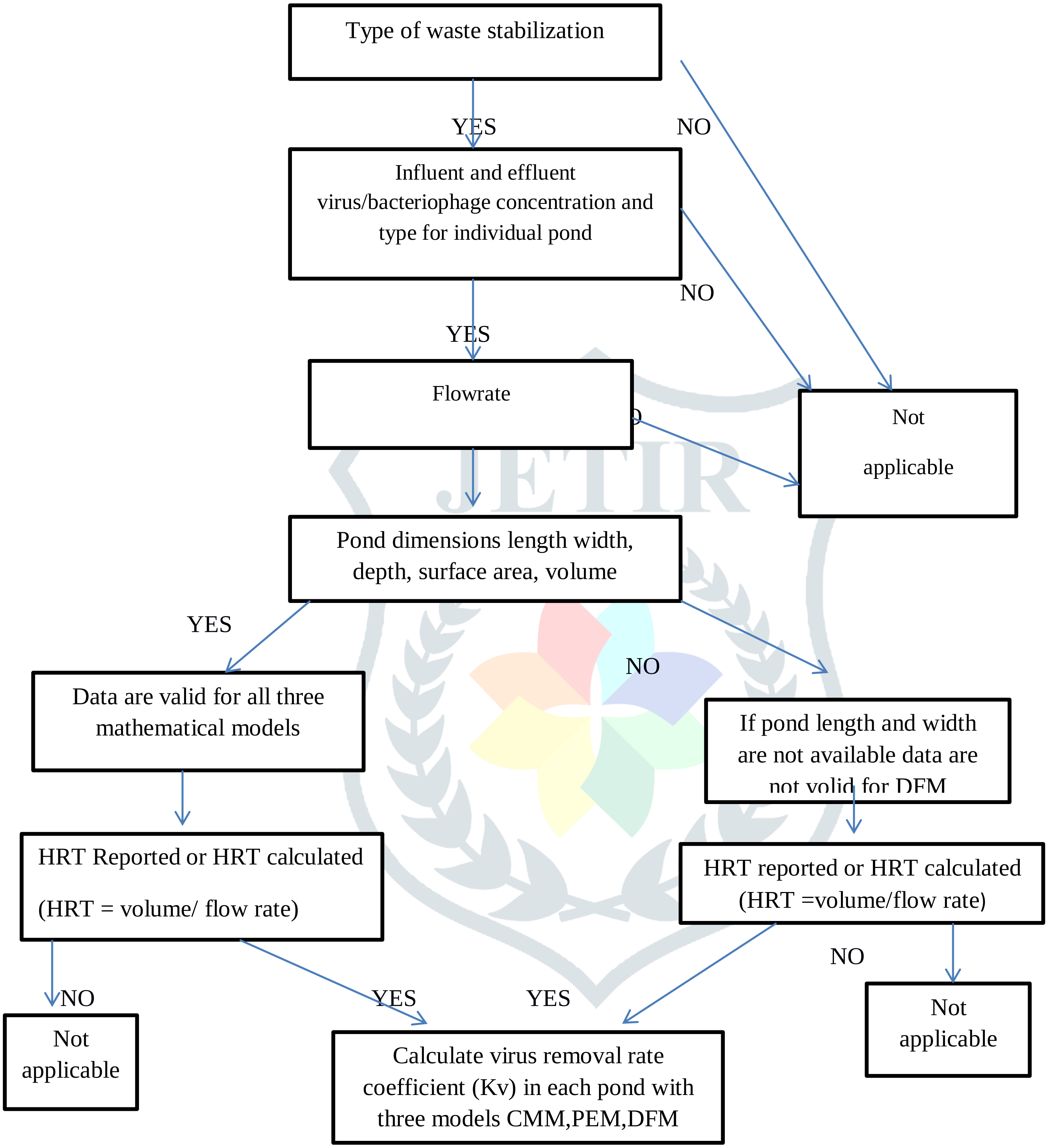

Figure 3.1: Method used to determine if reported waste stabilization pond characteristics and data were appropriate to be used for statistical analyses and mathematical modelling.

This paper Based on theoretical considerations for virus removal mechanisms in WSPs, The following environmental parameters were also recorded in the database: water temperature and pH (when reported), air temperature, solar radiation, and viral loading rates. The updated database included data from 34 publications and 44 WSP systems. These 44 WSP systems represented a total of 112 individual WSPs. Analyzing the data according to the selection criteria outlined in Figure 3.1. 332 data points were removed from the original set of

581 data points based on the selection criteria, yielding the final amount of 249 data points. There are more data points (n = 249) than ponds (p = 112) in the database because some authors reported multiple types of viruses for the same ponds and others reported virus concentrations under different operating conditions (i.e., different flows, time of year).

The distribution of ponds in the database can be broken down according to pond type: (1)facultative: 51 pond (147 data points); (2) maturation (includes 8 polishing): 47 pond (78 data points); (3) anaerobic: 14 pond(24 data points). The geographical distribution of the 44 unique WSP systems by country is: USA: 8; Spain: 5; India: 4; Bolivia: 4; Brazil: 4; Israel: 2; Venezuela: 3; New Zealand: 2; Australia: 1; South Africa: 1; United Kingdom: 2; China: 1; Thailand: 1; Chile: 1; France: 1; Egypt: 1; Colombia: 1; Germany; 1; Uruguay: 1. Histograms showing the latitudes and hydraulic retention times of each WSP data point (n = 249) in the updated database are provided in Figures 3.2 and 3.3, respectively. The distribution and frequency of viruses and bacteriophages reported in the WSPs for each WSP data point are displayed in Table 3.1 and Figures 3.4, 3.5.The HRTs for each WSP data point range widely from 0.4 days to 76 days, but approximately 80 percent of the data points came from ponds with HRTs of 20 days or less. Lastly, there are six different groups of viruses and four different groups of bacteriophages included in the database, with a total of more than twice as many viruses (v = 173) as bacteriophages (b = 76). These statistics represent the diversity of the physical, environmental, and operating conditions that exist in this WSP database.

Table 3.1: Overall distribution of virus and bacteriophage types among data points in the final waste stabilization pond database

Virus or Bacteriophage Group (strain)	Frequency
Culturable Enteric Virus	119
Rotavirus	46
Norovirus (GI)	5
Norovirus (GII)	2
Adenovirus	1
Somatic coliphage	32
F- specific coliphage	14
F- specific coliphage (MS2)	4
F- specific coliphage (RNA)	4
Coliphage (unspecified)	20
B. fragilis phage	2
Total viruses	173
Total bacteriophages	76

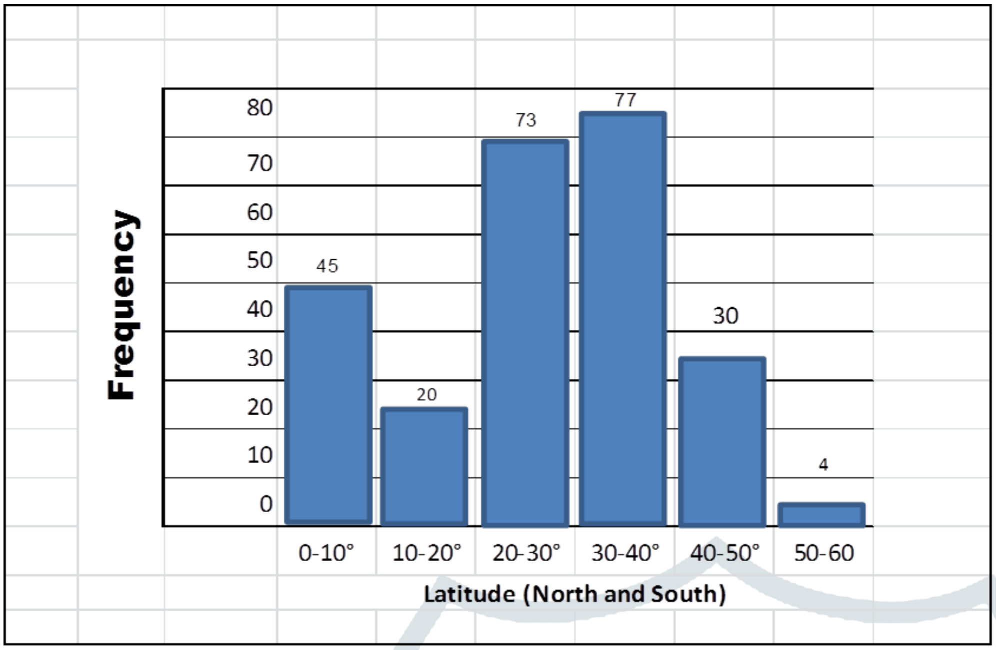

figure3.2: Frequency of data point latitudes for each waste stabilization pond in the final database

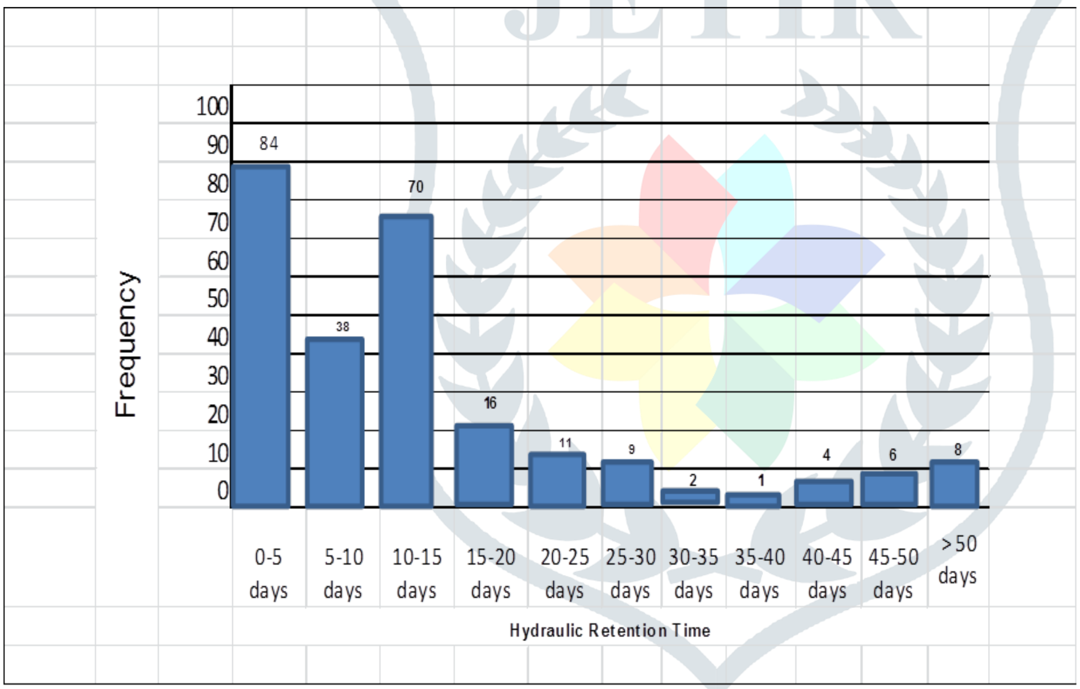

Figure 3.3: Frequency of data point hydraulic residence times (HRTs) for each waste stabilization pond in the final database

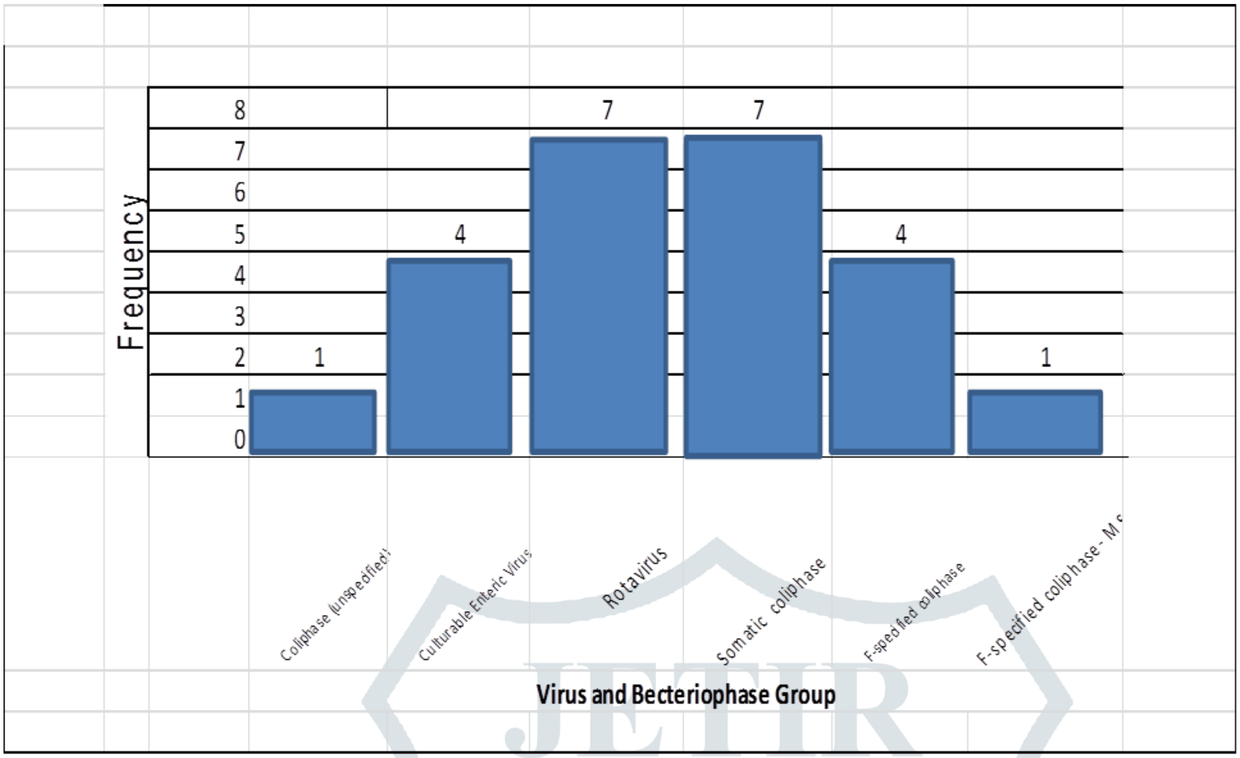

Figure3.3 Group of virus & bacteriophages targeted in anaerobic pond.

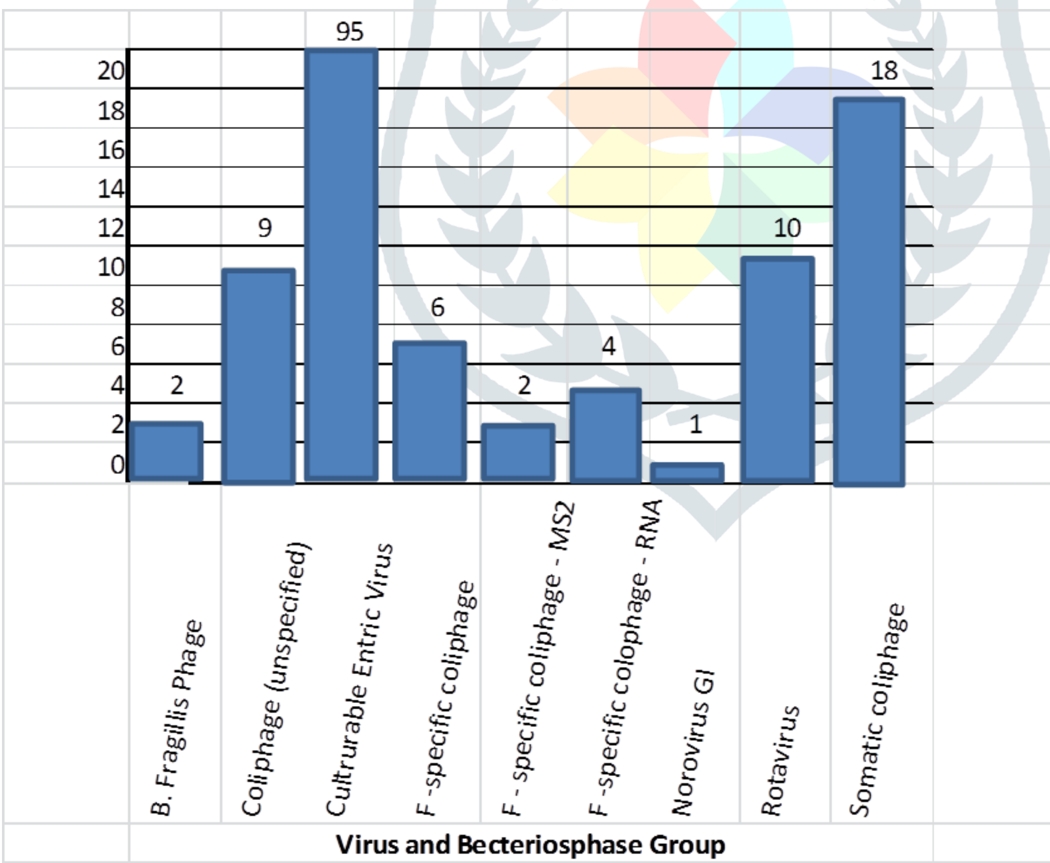

Figure 3.5: Groups of viruses and bacteriophages targeted in facultative ponds in the final database

3. LIMITATION

Some limitations of the data include:
(1) Several publications did not report the length, width, depth of the WSP that was studied; (2) It was often not specified whether the wastewater flow rates were actually measured or whether the design flow rates were reported.
(3)The mean theoretical HRT was often reported instead of the actual measured mean HRT; (4) The month of the year the data were collected was not always reported, which may affect.

The all above data collect form secondary sources. Which is collect from articles, papers etc.
The following techniques are use to modelling the extent of virus removal in waste stabilization ponds to support reuse of wastewater:

1. Mathematical models used to calculate virus removal rate coefficient
2. Statistical analysis of data
3. Descripitve statistics
4. Correlation analysis.
5. analysis of variance

4. SCOPE & RECOMMENDATION FOR FUTURE RESEARCH

WSPs One of the main advantages of WSPs is their ability to remove pathogenic organisms, such as protozoan cysts and oocysts, helminth eggs, and pathogenic bacteria. In fact, they are considered the most efficient form of wastewater treatment for pathogen removal without the addition of advanced disinfection treatment processes.
Some following points define the future scope:

1. This research is considered to be the first step that can be built upon in an advancing field of future research.
2. There are still many knowledge gaps in the literature about the mechanisms responsible for removing viruses in WSPs
3. The WSPs will be very useful in future for reuse wastewater for agriculture.
4. The recommended model from this research is capable of predicting virus effluent concentrations in WSPs when the initial virus concentration is known, but the reliability of its ability to predict virus removal rate coefficients may need to further validation in order to be used for design purposes.

Suggestions for further research include:
1. Derive an equation to convert the plug flow $K_{v,app}$ values to dispersed flow $K_{v,app}$ values to determine what implications this may have for WSP design. The dispersed flow model is most commonly used for design purposes, and this methodology for transforming K_b values has been developed for the design of WSPs for fecal coliform removal (von Sperling.2002).
2. In addition to this database, efforts to establish a larger database of paired influent and effluent concentrations for enteric viruses or bacteriophages in individual WSPs should be considered.
3. WSP system operators and/or nearby researchers should select a well-designed WSP system to continuously research and monitor. Dye-tracer studies should be performed to determine mean HRTs, several groups of enteric viruses or bacteriophages should be regularly measured, and apparent virus removal rate coefficients should be compared with intrinsic virus removal rate coefficient.

5. CONCLUSION

This is the first study that attempted to model the global extent of enteric virus and bacteriophage removal in individual waste stabilization ponds. The overall objective of this thesis research was to model the global extent of virus removal in individual WSPs to support the reuse of wastewater.

This was assessed by:

(1) Compiling a database of enteric virus and bacteriophage removal reported in the literature for individual WSPs.

(2) Deriving apparent virus removal rate coefficients ($K_{v,app}$) for each WSP type (anaerobic, facultative, and maturation ponds) using the complete mix, plug flow, and dispersed flow models.

(3) Identifying correlations and relationships between $K_{v,app}$ values and design, operational, and environmental parameters in WSPs.

(4) Developing alternative multiple linear regression equations to predict $K_{v,app}$ values and using mathematical models to predict effluent virus concentrations in WSPs.

(5) Determining the best mathematical model and assessing its potential to aid in WSP design and support waste.

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