WELCOME

TO

Presentation On

Performance Evaluation of Low-cost Greywater Treatment Systems

BY

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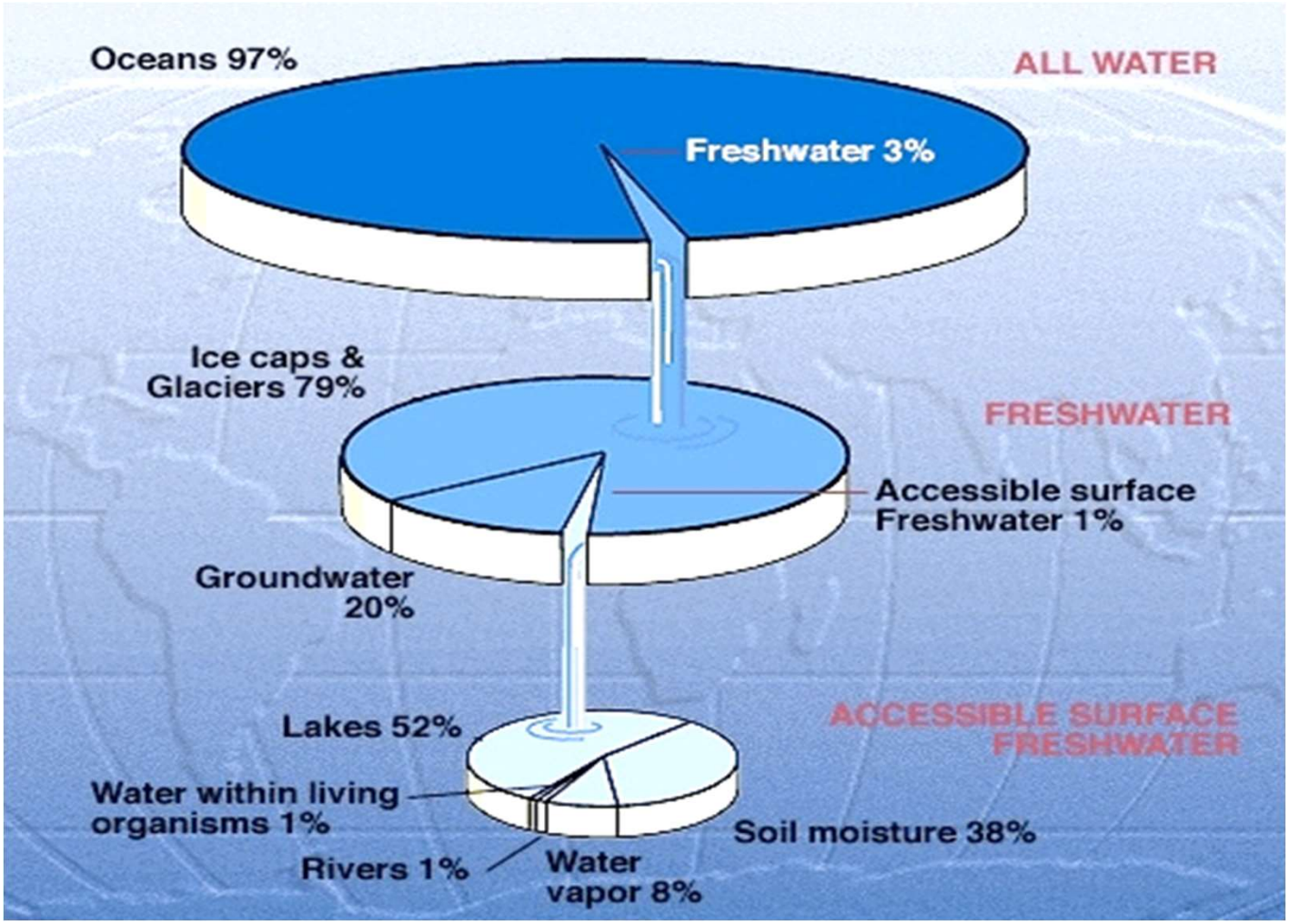
Outline of Presentation

- Introduction
- Relevance of Topic
- Objectives of Present Study
- Laterite Soil Vegetated Vermifilter (LSVVF)-Literature review, Scope, Material and Method, Result, Discussion and Conclusion
- Future Scope
- Bibliography
- Publications

Introduction

Distribution of water



Reference: Earth Forum, Houston Museum of Natural Science, 2018

Introduction…

Per Capita Water Availability in India

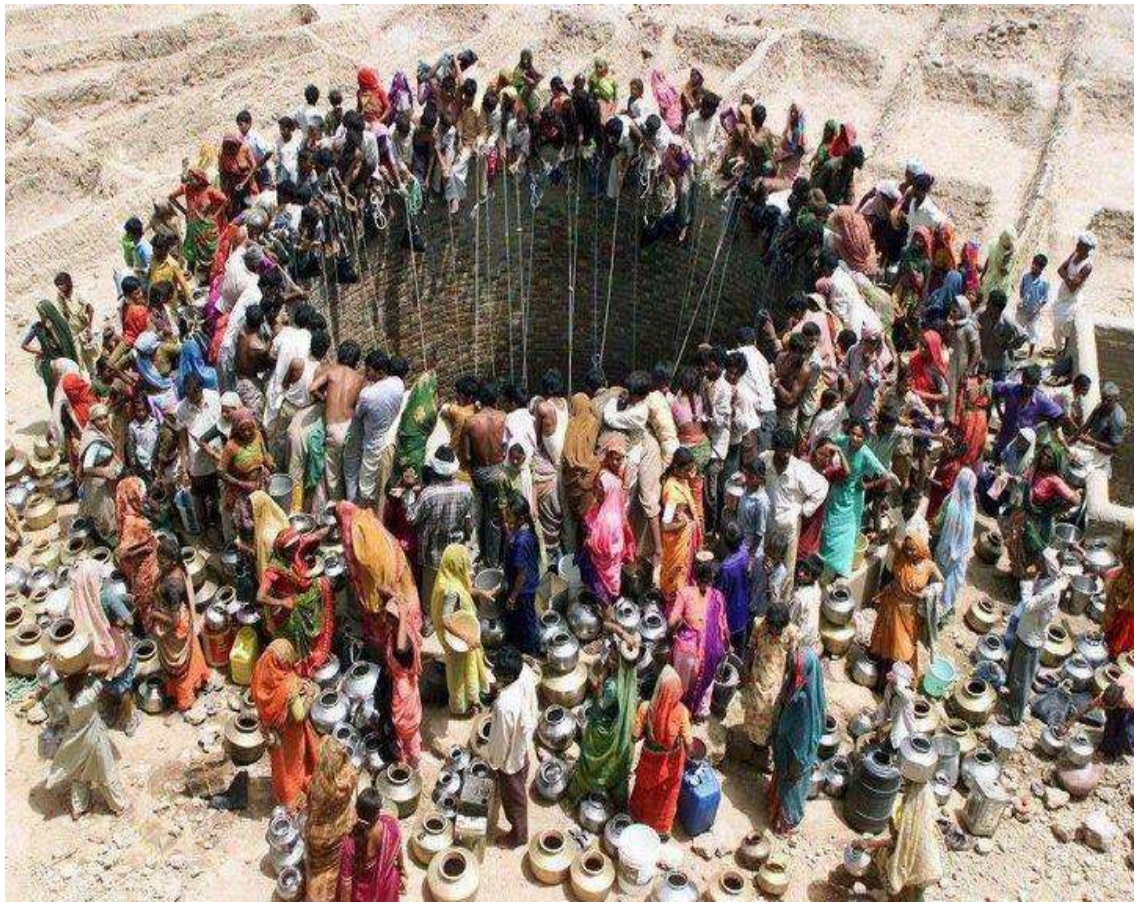
Year	Population (Million)	Per Capita water availability, m^3/year
1951	361	5177
1955	395	4732
1991	846	2209
2001	1027	1820
2025	1394	1341
2050	1640	1140

Source: Govt. of India, Ministry of Water Resources (2009)

Introduction…

❖ Water Shortage

- India faces serious water supply problems in many cities and hence measures have to be taken to conserve water or recycle the existing water.



Introduction…

❖ **Solutions for Water Shortage Problem**

- Rainwater Harvesting
- Watershed Management
- Recycle and reuse of wastewater

❖ **Greywater Qualities and Benefits of Recycling**

- **Greywater-** wastewater from bathing and cloth washing activities
  - Most reliable source
  - Less concentrated
  - Easy availability
- **Characteristics** –BOD_5 @20 °C 45 to 330 mg/L,
  TKN 2 to 23 mg/L, (NEERI, 2007)

Current Practices of Greywater Management in India

- Disposed into municipal sewerage system
- Partially treated and disposal into soak pit
- Raw GW used for gardening

- **There is a need to develop appropriate technology for GW treatment and reuse of treated GW as a part of sustainable development**

- **Systems of Decentralized GW Treatment**
  - Sand-gravel filter
  - Anaerobic filter
  - Constructed Wetland
  - Moving Bed bioreactor
  - Vermifilter
  - Carbon filter

Objectives of Present Study

- Critical evaluation of currently physical and biological systems of greywater treatment reported in literature with reference to their applicability to Indian conditions.
- Design and development of pilot scale greywater treatment system incorporating preliminary treatment, various combinations of physical and biological processes.
- Performance evaluation studies of various greywater treatment combinations for varied:
  - Organic Loading Rate (OLR),Hydraulic Loading Rate (HLR), detention time , and climatic conditions
- Design and development of laboratory scale vegetated vermifilter.
- Laboratory scale performance evaluation studies on vermifilter with laterite soil as a medium.
- Modeling and reaction kinetics study of greywater treatment systems.
- Cost-benefit analysis of greywater treatment system.

Part-I: Greywater Treatment by Vegetated Vermifilter

Methodology:

1.Introduction

2.Literature review

3.Research gaps and scope

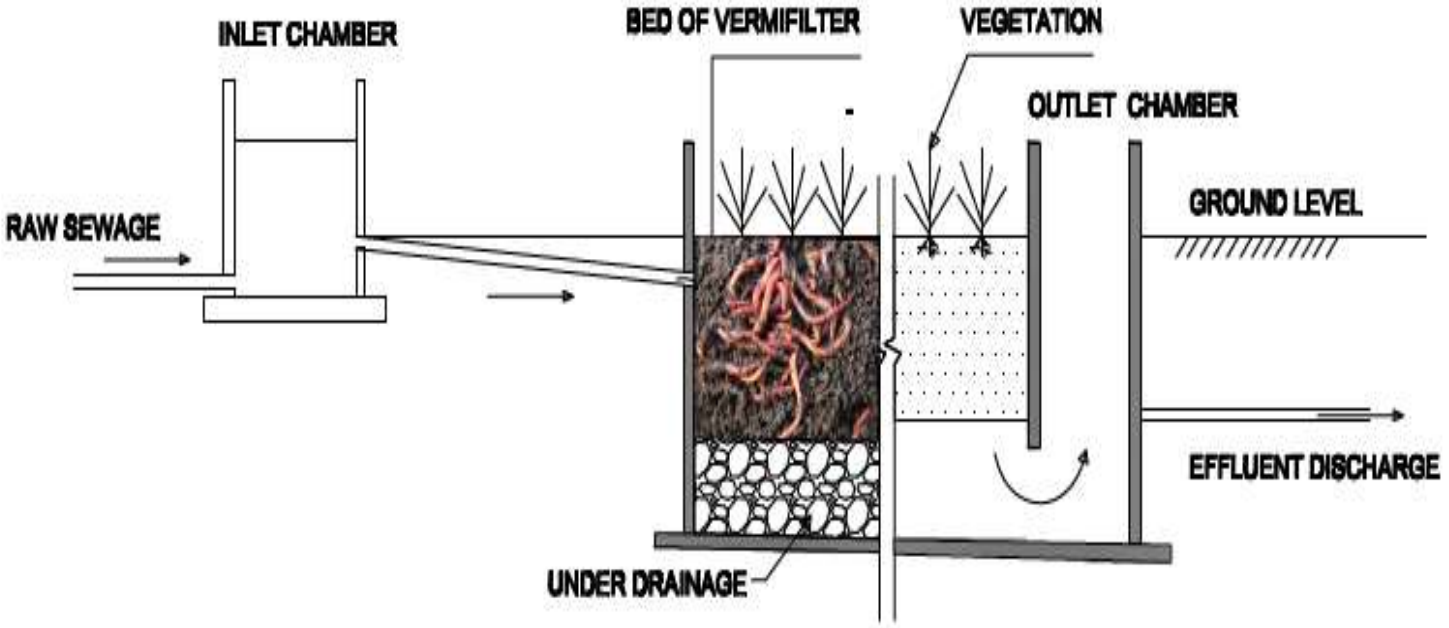
4.Materials and methods

5.Result and discussion

6.Conclusions

Introduction

GW Treatment by Vegetated Vermifilter



Literature Review

Authors and year	Type of wastewater	Results
Taylor *et al.,* (2003)	Domestic wastewater	BOD, COD and TDSS removal : 70 to 80%
Bajsa *et al.* (2003)	Domestic wastewater	Reduction in pathogens has been noticed.
Davison *et al.,* (2005)	Domestic wastewater	TSS:83% BOD : 81%, TN : 57%, P : 35%
Xing *et al.,* (2005)	Domestic wastewater	COD, BOD_5 and SS was 81–86%, 91–98%, and 97–98% respectively.
Munavalli and Phadatare, (2006)	Greywater	Emerging method was effective in reducing pollution strength of wastewater
Sinha *et al.,* (2008)	Domestic wastewater	BOD_5, COD and TDS was 90%, 92% and 90%, respectively

Literature Review…

Authors and year	Type of wastewater	Results
Kadam *et al.,* (2009)	Municipal wastewater using laterite soil-based Constructed Soil Filter	BOD (92 to less than 10 mg/L.) Suspended solid, (180 to 12-18 mg/L)and turbidity (140 to 5NTU.)
Liu *et al.,* (2009)	Ceramsite vermifilter filter for domestic wastewater treatment (Eisenia fetida)	COD, NH_4-N and TSS in the vermifilter were 50.9±6.9%, 69.3±4.9% and 91.9 ± 1.8%, respectively
Wang *et al.,* (2010)	vermifilter enhancement by a converter slag-coal cinder filter (domestic wastewater)	COD, BOD, ammonia nitrogen (NH_4^+-N) and phosphorus removal by the system were 78.0%, 98.4%, 90.3%, and 62.4% respectively

Literature Review…

Authors and year	Type of wastewater	Results
Tomar and Suthar, (2011)	urban wastewater by using Perionyx sansibaricus and Tcoco-grass	TSS: 88.6%, TDS: 99.8%, COD: 90%, NO_3: 92.7% and PO_4^{3-} : 98.3%.
Munavalli and Pise,(2012)	Domestic wastewater by natural hybrid system	The efficiency of the system for BOD_5 removal was observed to be 80 to 90% at 3 d HRT
Kumar *et al.,* (2015)	Evaluation of vermifiltration process using different natural ingredients as a media viz. river bed material, wood coal, glass balls, mud balls and using Eisenia fetida as an earthworm species	BOD_5 removal was found as 81.2%, 74.5%, 72.7% and 70.9 % respective filter media

Research Gaps in Vegetated Vermifilter

- Literature reviewed shows that the studies conducted by using vermifilteration for tropical climate region like India are few.
- Vegetated vermifilter was not assessed for its suitability to treat greywater.
- *Canna indica* vegetation was not used for greywater treatment.
- Effect of OLR HRT was not assessed
- Development of Lab scale vegetated vermifilter with laterite soil

Scope of work

- Design and development of laboratory scale vegetated vermifilter.
- Laboratory scale performance evaluation studies on vermifilter with laterite soil as a medium.

Schematic Sketch Experimental Set-up

Designed and developed for average flow rate of 150 L/d

Photographic view of Experimental Set-up

Methodology

Material and Methods

- Diluted greywater-BOD free raw tap water was used for dilution of greywater.

Operation of the system:

- OLR varied from 20 to 288 BOD_5 kg/ha.d and HRT 0.5,1,2,3 days in Laterite Soil Vegetated Filter (LSVF) and LSVVF.

Results and Discussion

Characteristics of Greywater

Sr. No.	Parameter	Unit	Diluted Raw GW	UF SGF	LSVF	LSVVF
1	pH	-	7.69±0.10	7.50±0.10	7.33±0.08	7.18±0.06
2	Acidity	mg/L as $CaCO_3$	92.59±16.8	75.24±14.1	45.7±12.2	33.92±11.4
3	Alkalinity	mg/L as $CaCO_3$	133.5±13.3	108.8±11.8	64.8±13.85	48.43±15.1
4	Chloride	mg/L	100.6±13.9	82±12.5	53.15±11.6	36±11.36
5	$BOD_5 20^oC$	mg/L	36±14.2	29±11.8	17.4±7.5	13.10±6.2
6	COD	mg/L	53.2±20.3	42.88±16.7	26.1±10.7	19.6±9.1
7	E C	µmhos/cm	614.66±194	479±167.2	305±92	217±77
8	TDS	mg/L	430.2±135	335±117	213.6±64	152±54
9	Turbidity	NTU	16.2±3.7	7.3±2.2	2.87±0.80	1.5±0.52
10	Temperature	^oC	29.9±1.2	29.9±1.1	29.8±1.1	29.9±1.1
11	TKN	mg/L	2.1±0.40	1.74±0.33	1.1±.0.24	0.8±0.23
12	Phosphorus	mg/L	0.83±0.13	0.69±0.13	0.44±0.10	0.34±0.08
13	MPN	No./100 ml	205±85	118±42	72±21	46±12

Results and Discussion…

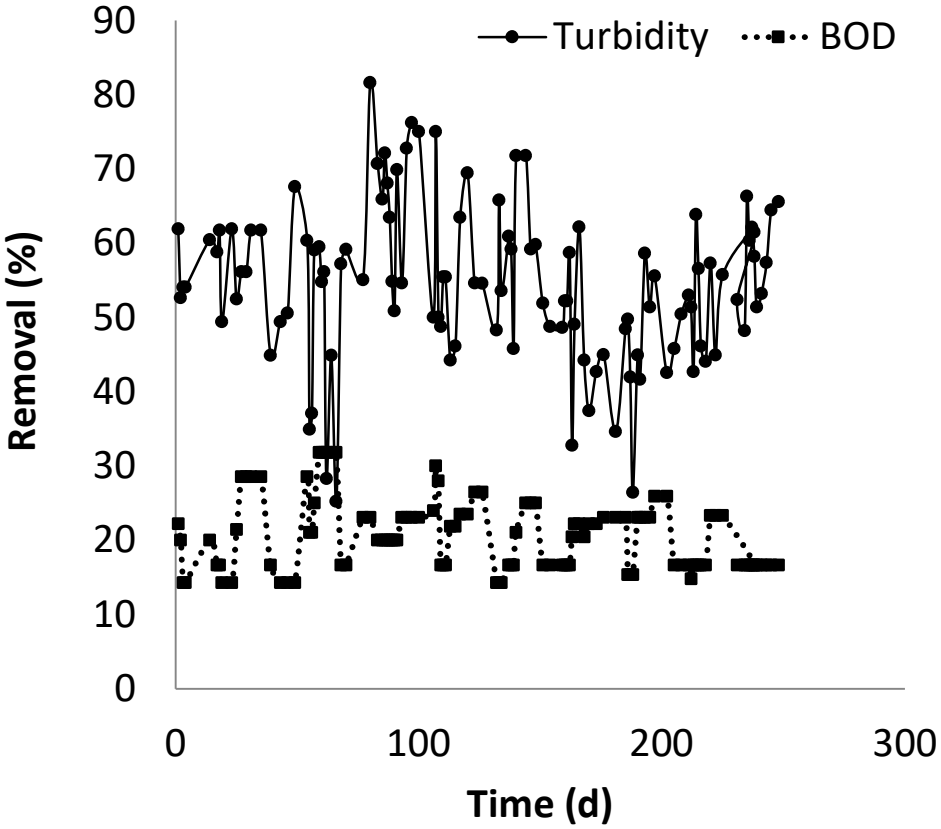
Greywater Characterization

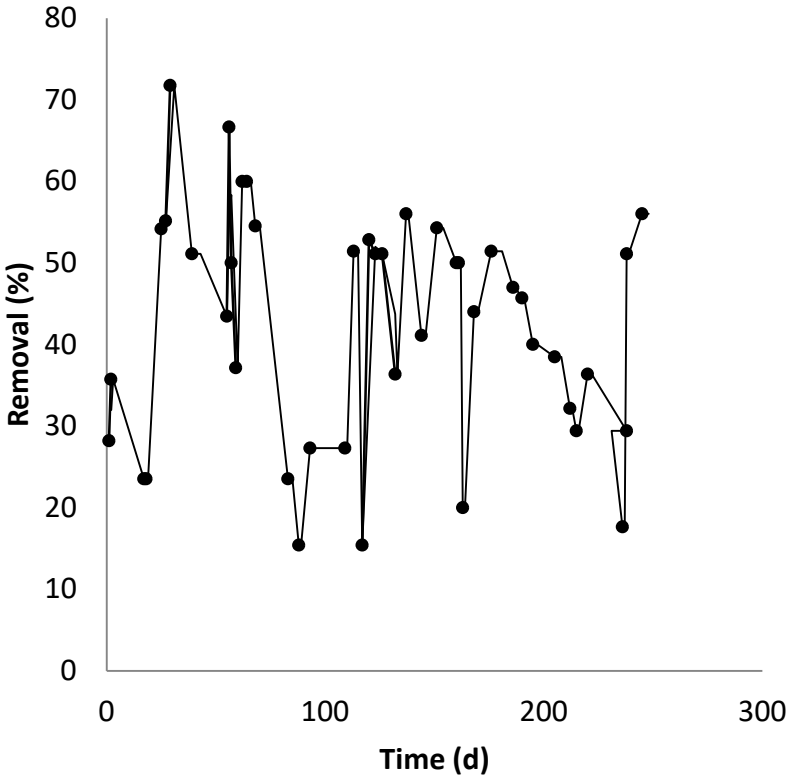
- BOD_5/COD value is 0.66 to 0.70.
- Indicating amenability of greywater for biological treatment.
- BOD_5: N: P for the diluted greywater was 45:2.62:1 to 43:2.66:1 and an ideal value 100:5:1 was reported by Metcalf and Eddy, 2003.
- The other characteristics show that the greywater is nearly neutral, low in ionic strength, and turbid.
- Pathogens is a significant observation.

Results and Discussion…

❖**Pre-Treatment:**

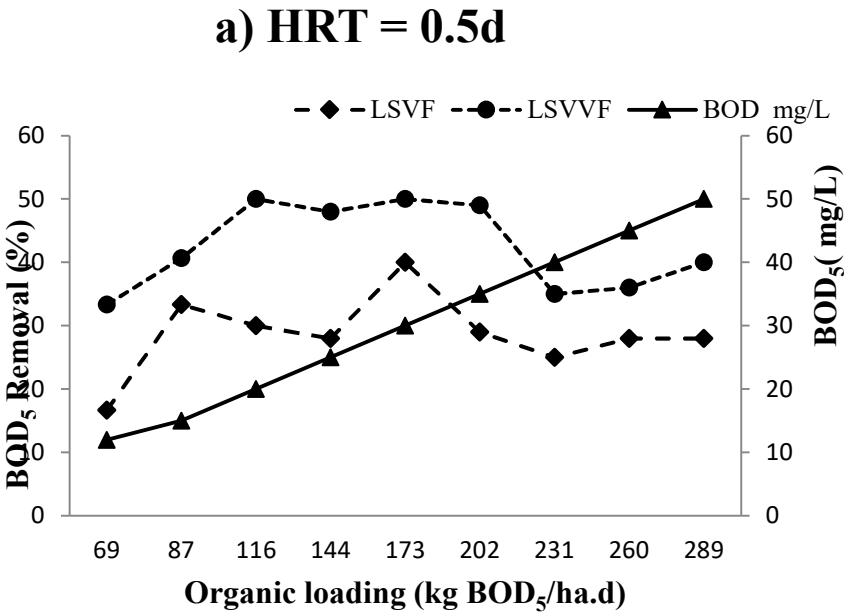
Turbidity, BOD_5 and pathogen by 55%, 21% and 42% respectively

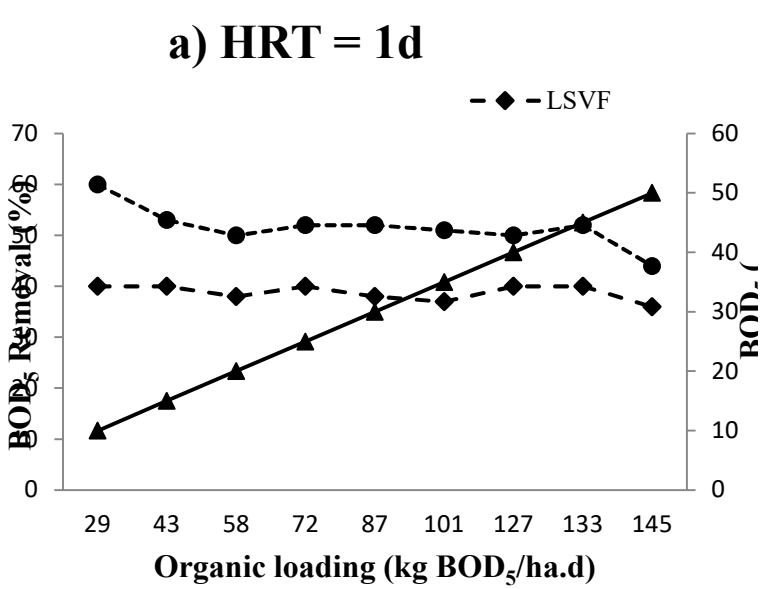


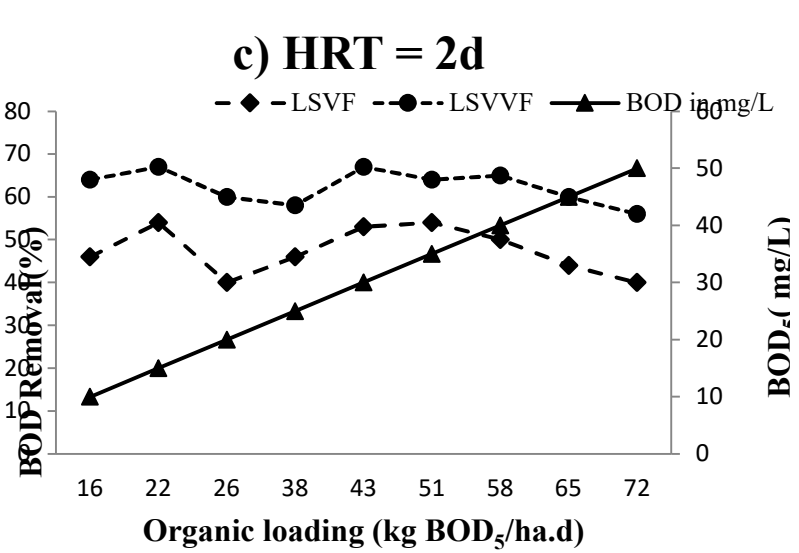


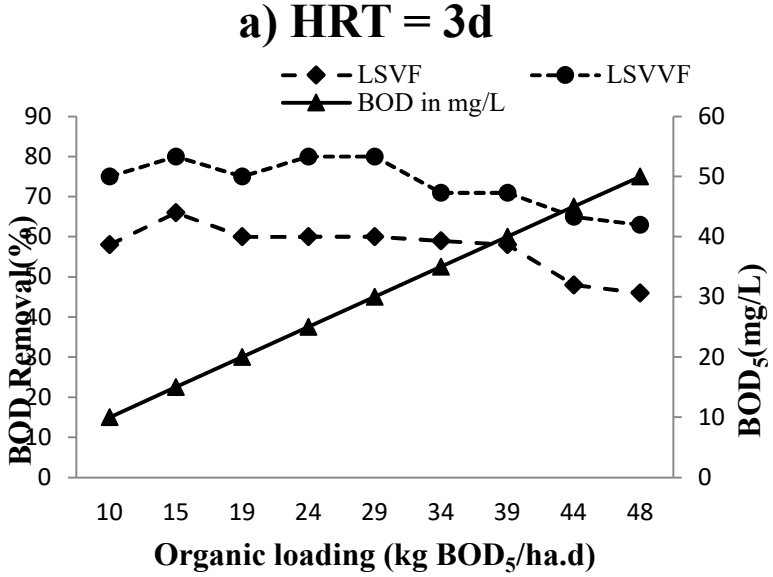
Effect of OLR on BOD Removal for various HRT

Results and Discussion…









Effect of OLR on BOD Removal for various HRT

Results and Discussion…

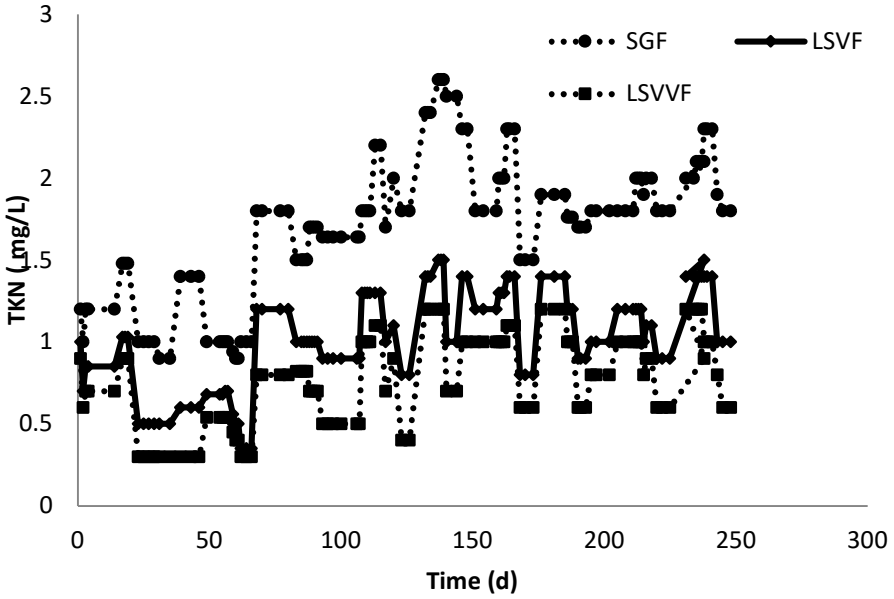
Removal of BOD_5

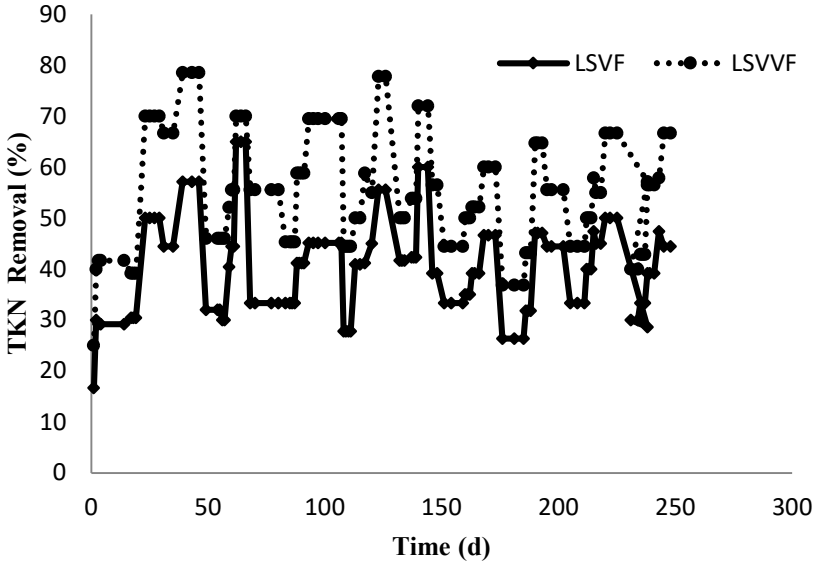
- LSVF found to be 50 to 60% and LSVVF 60 to 80% and total efficiency 80 to 90%
- The BOD_5 removal in LSVVF 20% more than LSVF
- The BOD_5 removal in LSVVF is maximum for OLR 145 kg BOD_5/ha.d and 3 d HRT

Results and Discussion…

TKN Removal

- TKN removal in LSVF is 40% and LSVVF 54%.
- TKN removal in LSVVF is 14% higher than LSVF

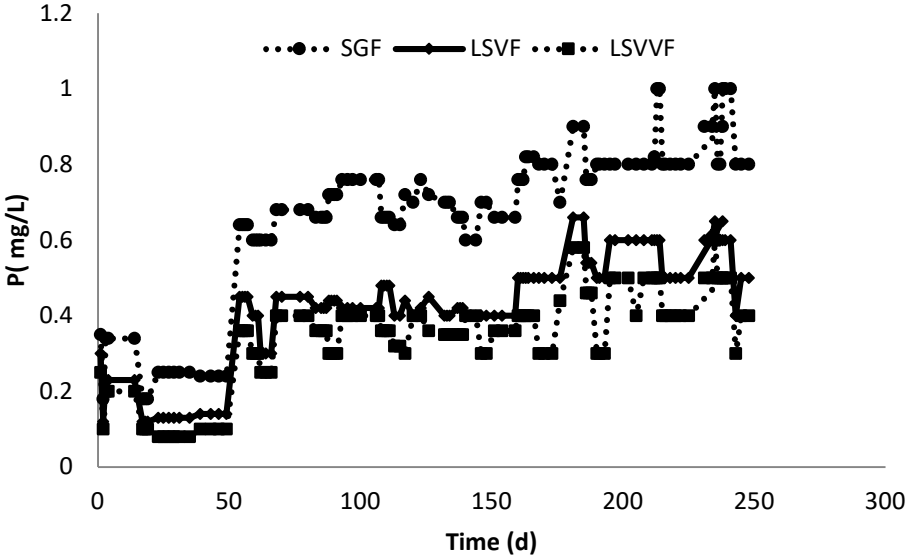


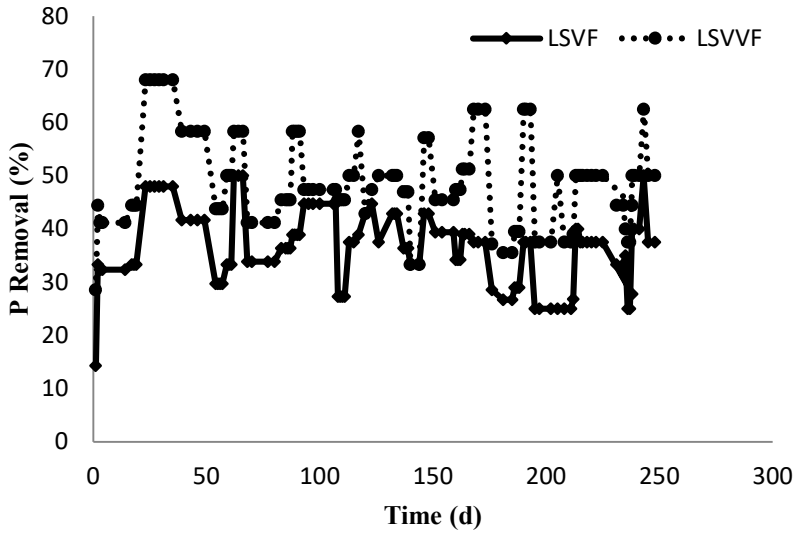


Results and Discussion…

Phosphorous Removal:

- Average removal of P in LSVF 36% and LSVVF 48% in.
- The LSVVF removes 12% more P from greywater.





Results and Discussion…

Average removal observed during study period

Parameter	Removal (%)			
	SGF	LSVF	LSVVF	Overall
Turbidity	55	60	79	90
BOD_5 @20ºC	21	50 to 60	60 to 80	63
TKN	17	30 to 50	40 to 64	61
Phosphorus	16.86	30 to 50	35 to 80	59

Conclusion : Study on LSVF and LSVVF

Literature Review

- Literature review shows that laterite as a medium in vermifilter with and without vegetation is not used for GW treatment.

Vegetated Filter

- Laterite soil vegetated vermifilter is found to be 20% more effective than laterite soil vegetated filter for GW treatment.
- Laterite as support medium is found to be suitable for growth of *Canna indica* in GW
- Variation in OLR & HLR affected the performance of the system in LSVVF. Secondary treatment showed better performance for BOD_5 removal. The recommended values of OLR and HRT are 145 kg BOD_5 /ha.d, and 3d respectively.
- Further, Laterite soil vegetated vermifilter also reduced TKN and P to significant extent.
- Vegetated vermifilter is found to be useful for treatment of GW at household level.

Future Scope

- For reducing cost of IOGTS, use of low cost construction material like hollow blocks and other low cost media may be used.
- The existing system can be modified to achieve the quality of treated greywater to disposal standard for natural water body the modification include following.

a) SSFCW converted to vertical flow CW thereby improving performance of secondary treatment.

b) Replacement of charcoal with activated carbon bed in tertiary treatment.

Publications

International Journals:

- Y. M. Patil and G. R. Munavalli (2016), **Performance Evaluation of an Integrated Onsite Greywater Treatment Systems in Tropical region,** Ecological Engineering (ELSEVIER) 492-500 Volume 95, (H Index-101, Impact Factor-2.35).

- Y. M. Patil and G. R. Munavalli (2018), "**Greywater Treatment by Vermifilter: A low-cost option for rural sanitation in India.",** International Journal of Recent Trends in Science and Technology,P-ISSN:2277-2812,E-ISSN-2249-8109, 26(2):21-29, Statperson Publishing Corporation, India.

- Y. M. Patil and G. R. Munavalli, **Greywater Treatment and research issues in greywater reuse for Sustainable development"**, in CTB's International Journal on Advances Analytical Techniques Vol. 1 (3), December 2014, PP-36- 42.

- Y. M. Patil and G. R. Munavalli (2012), **Greywater treatment and research issues in greywater for green development**: **A review**" in GJEAS ISSN: 2249-2631 Vol-2 Page-112-115.

- Y. M. Patil and G. R. Munavalli, **Simulation and Reaction Parameter Estimation in Subsurface Flow Constructed Wetland for Greywater Treatment,** Ecological Engineering (ELSEVIER) : under Process

Publications

International and National Conferences:

- Attended and presented paper on **"Reuse of greywater in Green building for smart city Development"** in International conference on Advances in Civil Infrastructure and Development of Smart cities (ICACIDS-2K2016) organized under TEQIP-II on 27th - 28th Feb. 2016 organized by Rajarambapu Institute of Technology, Rajaramnagar

- Attended and presented paper on **"Laterite Soil Vegetated vermifilter for greywater treatment an option for rural sanitation"** in AICTE SPONSORED National Seminar on 'Recent Practices and Application in Civil Engineering' 31st May -1st June 2013 organized by WCE, Sangli.

- Presented and published paper in All India seminar on Innovative Approaches for Low Cost Treatment of Water and Wastewater on " **Greywater recycling –A review of treatment options and applications"** organized by The Institution of Engineers (India), Kolkata; Kolhapur Local Center in collaboration with Department of Technology, Shivaji University, Kolhapur in Feb. 2012.

THANK YOU