Vermifiltration for Wastewater Treatment: Progress and Prospects in India

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An innovative Technology to make gold from Garbage and Silver from Sewage: Vermifiltration Technology
Background

Nation faces two severe problems

Water Scarcity

Sewage Disposal

Need of the Hour

Treatment of wastewater

- Sustainable method
- Decentralized method
- Eco-friendly method

Re-use of treated water

- In non potable uses
- In Agriculture
- Saves 80% water
Innovative Waste water treatment and Purification technology
Detoxification and Disinfection by Earthworms
Earthworms convert Waste water into Nutritive (NPK) water
Purified water can be reuse in Agriculture and non-potable purposes

Prof. Maria Soto – Chile
Dr. Rajiv Kumar Sinha – Australia
Er. George Hahn – USA
Prof. Upendra Patel – India
Dr. Ashok k Ghosh – India

Pioneer Researcher on VFT System

Commercialization of VFT System
TRANSCEM Agritech. ( TRANSPEK ), Baroda, Gujarat, India
Features of VFT / Role of Earthworms

**Features**
- Zero Waste Technology
- Self Promoted and Regulated
- Self Improved and Enhanced
- Easy to Construct
- Easy to Maintain and Operate
- No Odour and sludge
- No Chemicals used
- Liquid & Solid waste Management

**Earthworms**
- Body act as a Bio-Filter
- From Sewage, Removes
  - BOD by 98%
  - COD by 80-90%
  - TSS by 90-95%
  - TDS by 90-92%
  - TURBIDITY – 95%
  - CH4 – 99%
  - CO2 – 95%
- Bio-accumulate
  - Heavy Metals / EDC
  - Toxic Chemicals
- Ceolomic Fluid
  - Anti- Pathogenic
Application and Advantage of VFT

**APPLICATION**
- Sewage treatment
  - Rural/panchayat projects
  - Small Municipalities
  - Factories
  - Resorts / Hotels / Clubs
  - Housing Colonies
- Organic Industrial Effluent
  - Dairy
  - Vineyards / Distilleries
  - Food processing units
  - Fisheries/Meat/Poultry units

**ADVANTAGES**
- Simple and easy operation
- Low operating and maintenance costs
- Low energy input
- No sludge formation
- Contaminants convert into a Coin
- Treated water becomes nutrient rich
- Natural way of fertigation
- Cost saving on artificial fertilizers
- Aerobic process hence no odour
Research Objectives

Methodology
1. Fabrication of a Vermi-filtration unit for wastewater recycling
2. Bio-Physico-Chemical analysis of Vermiaqua and wastewater

Experiments
3. Growth Impacts of Vermiaqua on Rice Crops (*Oryza sativa*)
4. Performance of Vermiaqua on Onion (*Allium cepa*)
5. Vermifiltration of Arsenic contaminated water
1. Fabrication of a Vermi-filtration unit for wastewater recycling
### Table 1. Graded layers of vermibed

<table>
<thead>
<tr>
<th>Layers</th>
<th>Layer thickness size (cm.)</th>
<th>Test unit</th>
<th>Materials</th>
<th>Control unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top layer</td>
<td>30</td>
<td>soil + vermicompost + earthworms</td>
<td>soil + vermicompost</td>
<td></td>
</tr>
<tr>
<td>2nd layer</td>
<td>20</td>
<td>sand + sawdust</td>
<td>sand + sawdust</td>
<td></td>
</tr>
<tr>
<td>3rd layer</td>
<td>10</td>
<td>small sized pebbles</td>
<td>small sized pebbles</td>
<td></td>
</tr>
<tr>
<td>4th layer</td>
<td>10</td>
<td>medium-sized pebbles</td>
<td>medium-sized pebbles</td>
<td></td>
</tr>
<tr>
<td>5th layer</td>
<td>10</td>
<td>large sized pebbles</td>
<td>large sized pebbles</td>
<td></td>
</tr>
<tr>
<td>Bottom layer</td>
<td>01 mm</td>
<td>cotton cloth layer</td>
<td>cotton cloth layer</td>
<td></td>
</tr>
</tbody>
</table>

### 2. Bio-Physico-Chemical analysis of Vermiaqua and wastewater

### Table 2. Bio-Physico-chemical parameters analysis of wastewater, Control and Vermiaqua

<table>
<thead>
<tr>
<th>Parameters analysed</th>
<th>Control</th>
<th>wastewater</th>
<th>Vermiaqua</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odour</td>
<td>Unpleasant</td>
<td>Unpleasant</td>
<td>Odourless</td>
</tr>
<tr>
<td>Colour</td>
<td>Hazy</td>
<td>Dark Brown</td>
<td>Pale yellow</td>
</tr>
<tr>
<td>Turbidity [NTU]</td>
<td>15.0</td>
<td>100</td>
<td>5.0</td>
</tr>
<tr>
<td>pH</td>
<td>8.2</td>
<td>8.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Nitrate [mg/l]</td>
<td>3.0</td>
<td>1.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Iron [mg/l]</td>
<td>1.5</td>
<td>3.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Phosphorous [mg/l]</td>
<td>0.1</td>
<td>BDL</td>
<td>BDL</td>
</tr>
<tr>
<td>BOD [mg/l]</td>
<td>30</td>
<td>218</td>
<td>19</td>
</tr>
<tr>
<td>E. coli</td>
<td>++++</td>
<td>++++</td>
<td>---</td>
</tr>
</tbody>
</table>

BOD, Biological Oxygen Demand; +, Positive; -, Negative; Each Value is average of 3 observations; BDL, Below Detectable Limit

Fig.5. *E.coli* test vial

A = control, B= wastewater, C= vermiaqua
Experiment - 1

Growth Impacts of Vermiaqua on Rice Crops (Oryza sativa)
Methodology

1) Selection of Rice (Oryza sativa) seeds

BIHAR BEEJ —RAAJ SHRI‖ —Bihar Rajya Beej Nigam Limited, Patna.

2) Inoculation of Seeds into Farm Soil

Seed was inoculated in farm at ten inch by ten" distance by —SHRI VIDHI METHOD.

3) Use of Vermiaqua in farm of Oryza sativa

1 litre of Vermiaqua mixed with 9 litre of water was sprayed continuously on the plant at the interval of 15 days from top portion of the plant to root.
1) Assessment of Oryza sativa Plant Height

The plant height was increased by 26.77% during entire period of study.
2) Assessment of *Oryza sativa* Single Branch Seed Count

The Seed count was increased by 110.72%
Results

3) Assessment of *Oryza sativa* Single Branch Seed Weight

The Seed weight was increased by 109.12%
Results

4) Assessment of *Oryza sativa* width wise shoot growth

The width wise shoot growth is increased by 255.21 %
Experiment -2

Performance of Vermiaqua on Onion (*Allium cepa*)
1. Allium cepa root germination at different concentration of Vermiaqua

Root Germination at 0 hr.  
Germination at 5th Day
2. Morphological changes in root germination
Table 3. Morphological Properties of Germinated roots

<table>
<thead>
<tr>
<th>Root quantity</th>
<th>Root Length [c.m.]</th>
<th>Root Colour</th>
<th>Root forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>15</td>
<td>3.99</td>
<td>White</td>
</tr>
<tr>
<td>wastewater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>11</td>
<td>1.78</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>03</td>
<td>0.8</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>00</td>
<td>0.0</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-7}$</td>
<td>04</td>
<td>3.6</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>16</td>
<td>2.2</td>
<td>White</td>
</tr>
<tr>
<td>Vermiaqua</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>09</td>
<td>3.91</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>26</td>
<td>2.49</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>40</td>
<td>3.40</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-7}$</td>
<td>21</td>
<td>2.70</td>
<td>White</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>24</td>
<td>4.68</td>
<td>White</td>
</tr>
</tbody>
</table>

[c.m.] = Centimetre
3. Chromosomal abnormalities observed at $10^{-9}$ wastewater concentration

(i, Uneven Metaphase Chromosomal Separation; ii, Sticky Metaphase Chromosome; iii, Sticky Anaphase Chromosome; iv, Laggard Metaphase Chromosome; v, Metaphase Chromosomal Deletion)

4. Chromosomal abnormalities observed at $10^{-5}$ Vermiaqua concentration

(i, ii, Anaphase dibridges or Chromosomal dibridges)
<table>
<thead>
<tr>
<th></th>
<th>wastewater [10^{-9}]</th>
<th>Vermiaqua [10^{-5}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interphase</td>
<td>No Abnormalities</td>
<td>No abnormalities</td>
</tr>
<tr>
<td>Prophase</td>
<td>No Abnormalities</td>
<td>No abnormalities</td>
</tr>
<tr>
<td>Metaphase</td>
<td>Uneven Separation</td>
<td>No abnormalities</td>
</tr>
<tr>
<td></td>
<td>Sticky chromosome</td>
<td>No abnormalities</td>
</tr>
<tr>
<td></td>
<td>Laggard chromosome</td>
<td>No abnormalities</td>
</tr>
<tr>
<td></td>
<td>Chromosomal deletion</td>
<td>No abnormalities</td>
</tr>
<tr>
<td>Anaphase</td>
<td>Sticky chromosome</td>
<td>Dibridges</td>
</tr>
<tr>
<td>Telophase</td>
<td>No Abnormalities</td>
<td>No abnormalities</td>
</tr>
</tbody>
</table>
Experiment -3

Vermifiltration of Arsenic contaminated water
1. Preparation of different concentration of Arsenic trioxide sample

   Different concentrations of 10,000 µg/L, and 20,000 µg/L were prepared

2. Filtration of Arsenic through Vermifiltration process

   Arsenic sample was allowed to pass 50 - 60 drops per minute through filter

3. Analysis of treated Arsenic sample by AAS

   50 ml treated Arsenic sample was analyzed

4. Analysis of Earthworms’ body tissue by AAS

   0.5 mg treated Arsenic sample was analyzed
<table>
<thead>
<tr>
<th></th>
<th>Control 10,000 µg/l</th>
<th>Test 1 10,000 µg/l</th>
<th>Test 2 20,000 µg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vermifiltered Arsenic Water</strong></td>
<td>80.780 µg/l</td>
<td>7.716 µg/l</td>
<td>6.186 µg/l</td>
</tr>
<tr>
<td><strong>Earthworms’ Body Tissue (0.5 mg)</strong></td>
<td>No Earthworms Were Used</td>
<td>127.9 µg/l</td>
<td>63.81 µg/l</td>
</tr>
<tr>
<td><strong>Soil Testing (0.5 mg)</strong></td>
<td>19.58 µg/l</td>
<td>144.7 µg/l</td>
<td>92.37 µg/l</td>
</tr>
</tbody>
</table>
Research Conclusion
1. Vermifiltration Units are Sludge-free, Noise-free and Low or No Electricity requiring systems for operation.

2. Earthworms upgrade the performance of Fabricated Systems with an integrated methods of Wastewater Purification - Biological, Chemical and Physical.

3. Vermiaqua highly promotes the germination of Roots Growth in Onion and also inhibited any Chromosomal Abnormalities, while the Raw Wastewater inhibited Germination, Growth and produced great Chromosomal Abnormalities.
4. Farmers should be advised NOT to use Raw Wastewater for Farm Irrigation which has become common practice due to growing Water Scarcity all over the world.

5. There is also need to commercialise this Vermifiltration Technology in the interest of Farmers. It will save huge groundwater (which is depleting resource all over world) for Farm Irrigation & also promote good Crop growth with less use of fertilizers as the Vermifiltered Water is also Nutritive.
Future Prospective

1. To analyze chemical conversion of wastewater and Arsenic through the Vermifilter pathway.

2. To identify the Gene/s responsible for toxic and Arsenic toxic tolerance capacity in Earthworms.

3. To identify the role of Microbes present in gut of Earthworms in conversion of wastewater and Arsenic
Avoid Using Clean Water
THANK YOU...