

Assessment and improvement of quality of treated wastewater from Hantana sewage treatment plant using biochar

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1.Introduction

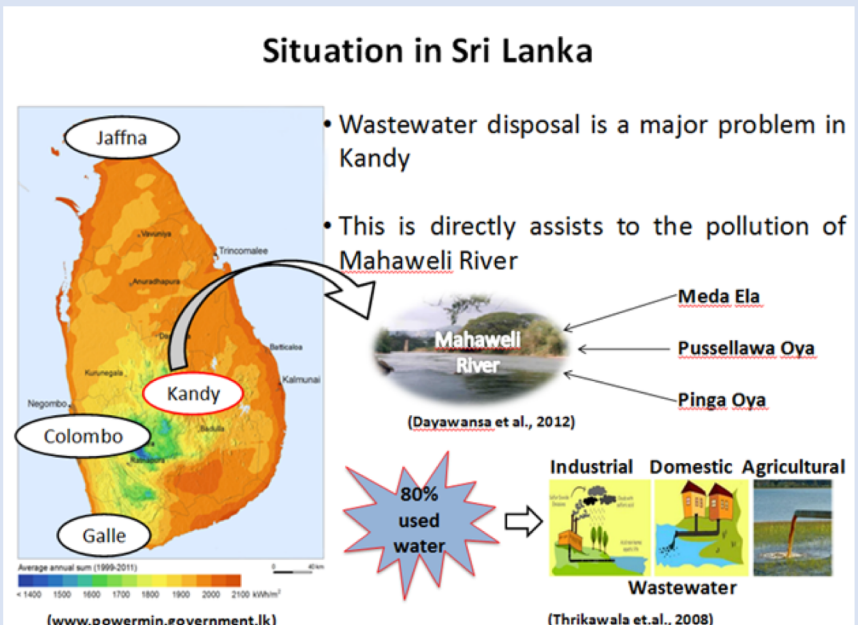
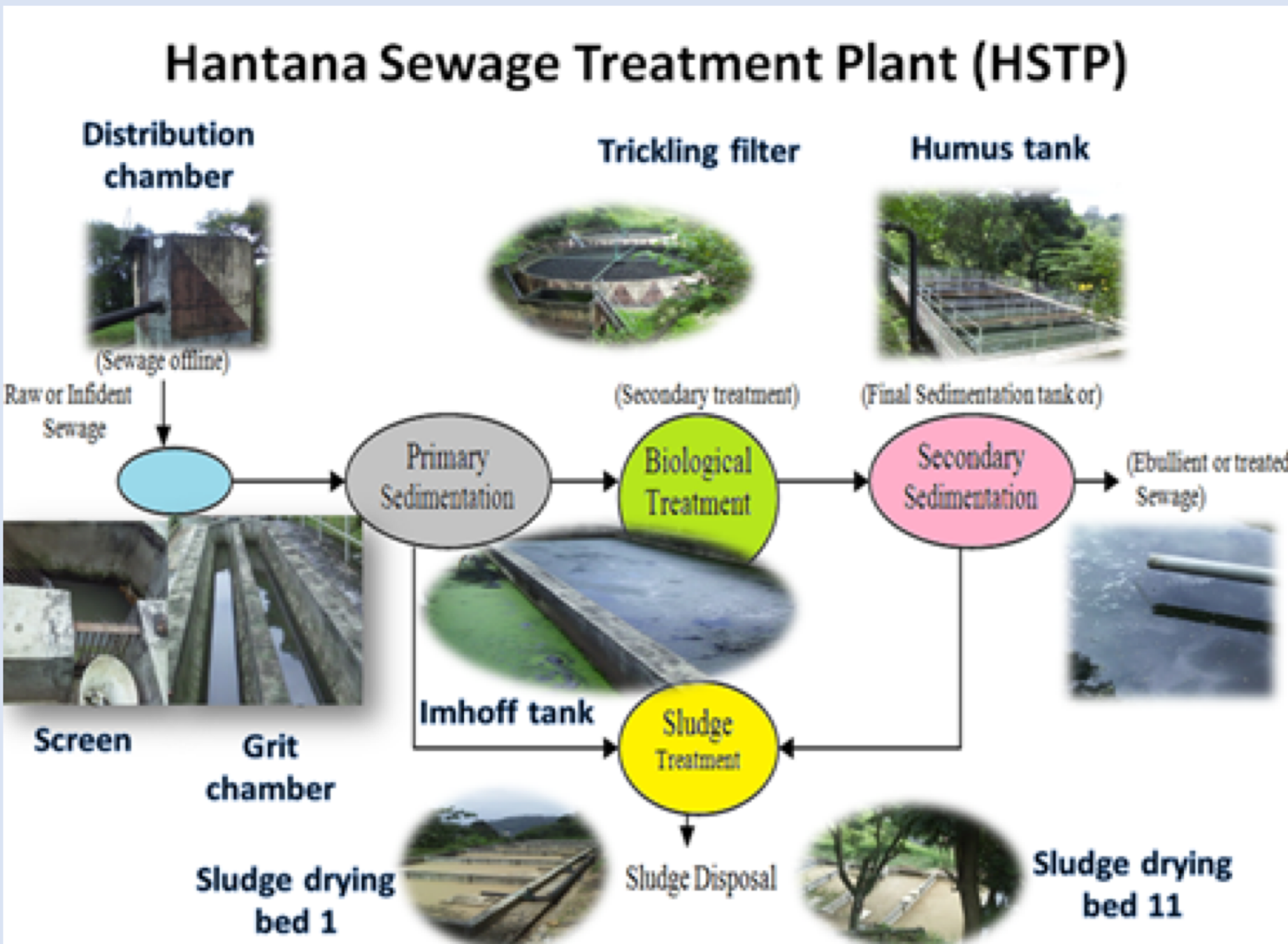


Fig.1 Process flow of HSTP (aboutcivil.org)

Hantana Sewage Treatment Plant (HSTP)

• To carryout a better treatment for sewage and wastewater from Hantana housing scheme, Kandy, Sri Lanka

• Treatment process of Hantana Sewage Treatment Plant has following treatment steps (EPA,1997):

- Preliminary Treatment - Removal of wastewater constituents such as rags, sticks, floatables, grit and grease
- Primary Treatment - Removal of a portion of the suspended solids and organic matter from the wastewater
- Secondary Treatment - Removal of biodegradable organic matter and suspended solids
- Tertiary Treatment - Removal of residual suspended solids

• There are significant problems in the system that may affect to the treated water quality

• Therefore; the current process steps can be evaluated for better treatment while introducing environmental friendly technology to enhance the quality of treated water

Biochar as a treatment material for treated wastewater

• The use of biological waste material as a treatment material for wastewater is not popular in Sri Lanka

• A carbon rich amendment such as biochar is applied for treated effluent in Hantana STP to improve its treated water quality

Biochar

- Biochar is a stable carbon rich by product
- Produced by thermal decomposition of organic material (biomass) under limited supply of oxygen(O₂), and at relatively low temperatures (<700°C)
- Eg: hard wood, rice husk, animal manure, food processing waste (Lehmann et al., 2006)

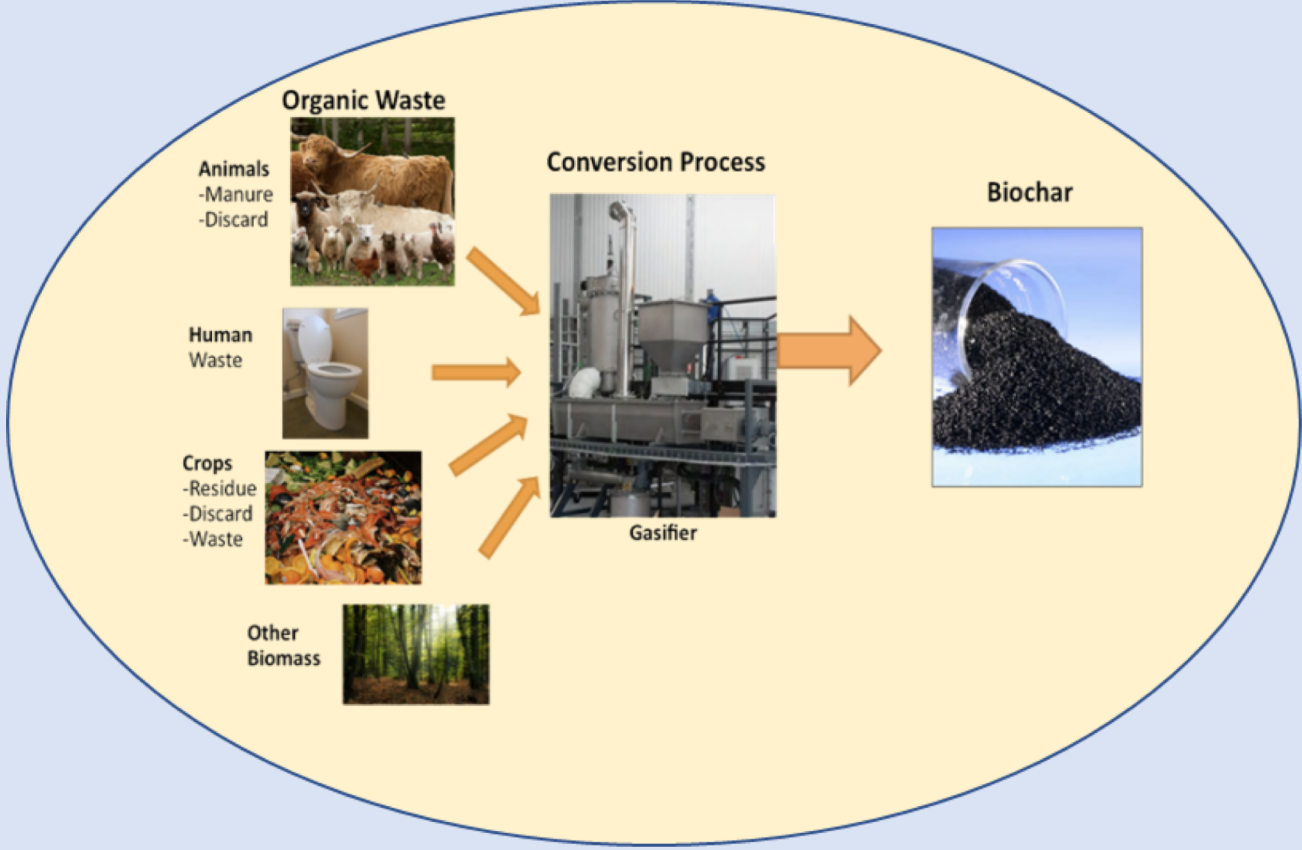


Fig. 2 Production of biochar (art.co.im)

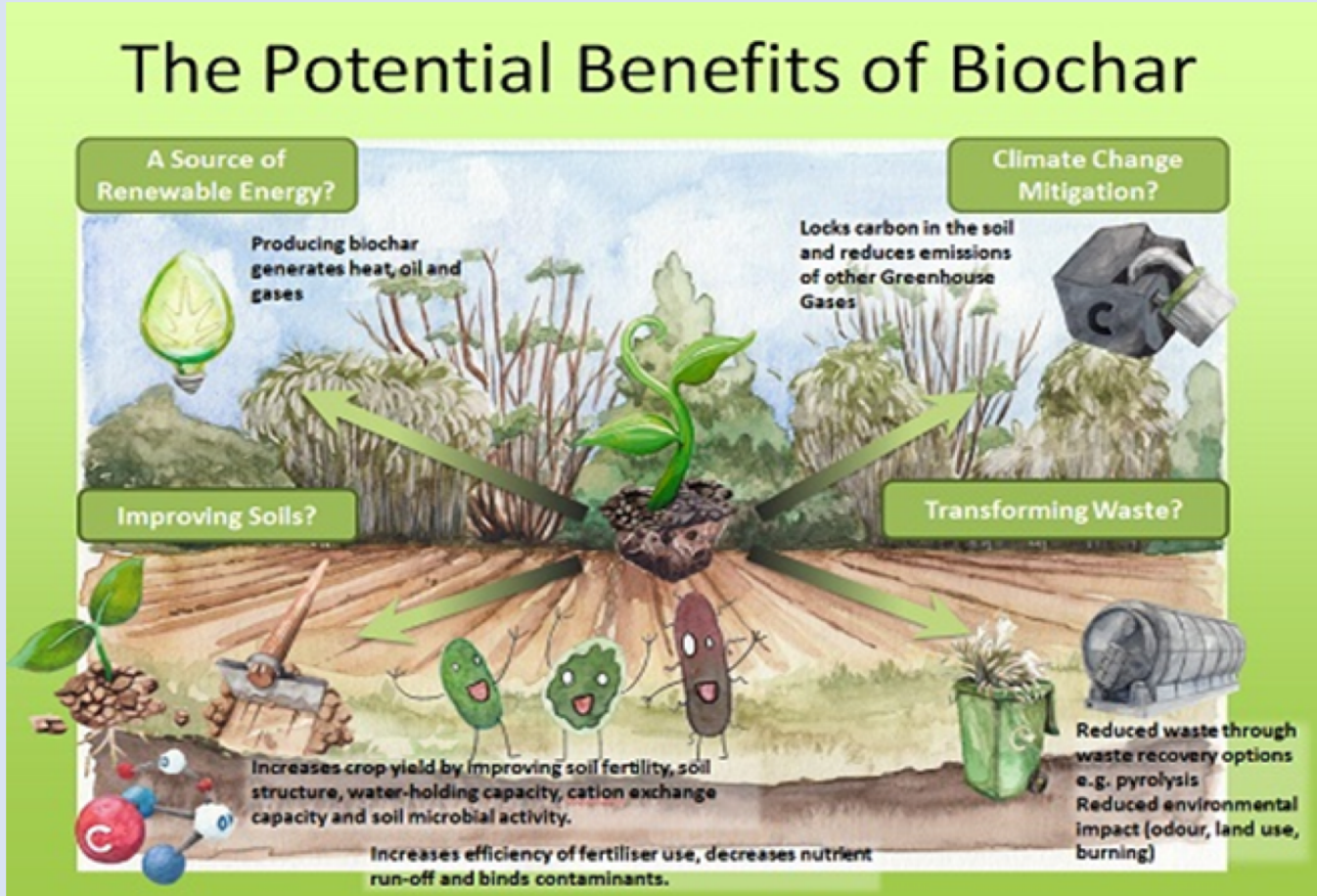


Fig. 3 Benefits of biochar (quora.com)

2. Materials and Methods

Sample collection and laboratory analysis

• Samples were collected during six months at regular time intervals and the selected sampling locations are Raw sewage, Grit chamber, Imhoff tank, Humus tank, Treated outlet

• Samples collected from each sub process were analyzed for

Physical and chemical parameters: Electrical Conductivity, pH, nitrate(NO₃⁻), nitrite(NO₂⁻), free ammonia (NH₄⁺)

Biological Oxygen Demand (BOD)

Chemical Oxygen Demand(COD)

Total Suspended Solids (TSS)

Heavy metals (Zn (II), Cd (II), Cu (II), Pb (II) (only for treated outlet)

• A constant volume of treated water samples were used to add a series of biochar mass under selected time intervals with constant stirring

• The resulted samples were analyzed for pH, Electrical Conductivity, nitrate, BOD, COD

• Biochar collected from dendro power plant at Thirappane, Anuradhapura

• This is a waste by product of electricity generation process which Albesia wood is used as a raw material and that is gasified at 700-1000 ° C

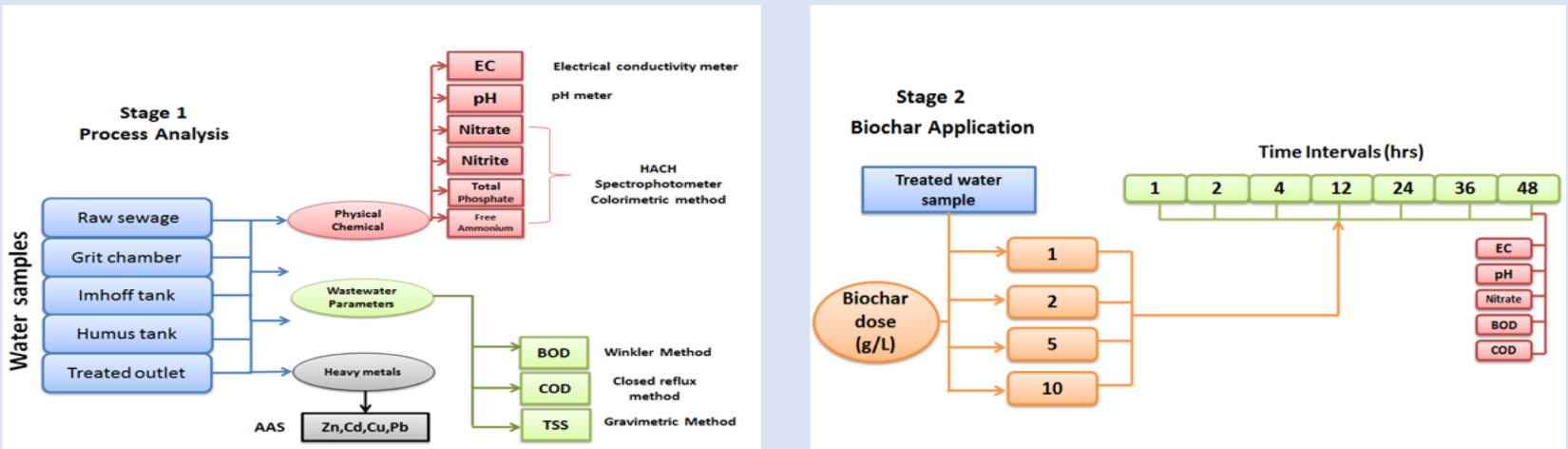


Fig. 4 Analytical plan for the methodology

Statistical analysis

• The collected data was tabulated and analyzed statistically, using arithmetic mean.

3. Results and Discussion

Characteristics of biochar

Proximate analysis								
pH	Moisture (%)	Mobile matter (%)			Ash (%)	Resident matter (%)		
10.10	6.50	9.90			19.70	63.80		
Ultimate analysis								
C (%)	H (%)	O (%)	N (%)	S (%)	Molar H/C	Molar O/C	Molar [(O+N)/C]	Surface area / m ² g ⁻¹
50.00	1.00	44.00	0.50	0.10	0.02	0.88	0.89	714.00

Fig. 6 Pre characterized proximate and ultimate analyzed data for biochar (Herath et al., 2015)

Evaluation of the treatment process

- A 30.0 % of BOD of treated water was removed by the primary treatment and the average BOD of treated water was 0- 30 mg/L
- It was found that maximum reduction percentage of COD was three times that of the minimum reduction of COD and also average COD of treated water was 30.0- 130.0 mg/L
- The TSS in Grit Chamber was less than the TSS in Raw sewage with average TSS of 0-30.0 mg/L in treated water
- Overall process had a pH in 6.68-7.18 and Electrical Conductivity (EC) 590-710 µS/cm
- Initial NH₄OH (NH₄⁺) concentration (15.0-40.0 mg/L) automatically converted to NO₃⁻ (0.5-4.5 mg/L) at final outlet of the current treatment process
- All the measured heavy metals (Zn (II), Cd (II), Cu (II), Pb (II)) were less than the acceptable level.
- It was found that the current water treatment process is effective with respect to BOD, COD, TSS and nitrate.

Relationship of process steps

- There was a significant different for pH, BOD, COD and TSS in Raw sewage and Humus Tank
- Furthermore, the BOD, COD and TSS have been observed a significant different among Raw Sewage and Treated outlet
- The nitrite level was significantly different in Raw sewage to Imhoff tank and Humus Tank

Biochar application for the treated wastewater outlet

- A significant reduction of nitrate was observed with 5 g/L biochar dosage while a considerable amount of BOD and COD indices have been reduced with 5g/L and 10 g/L biochar doses

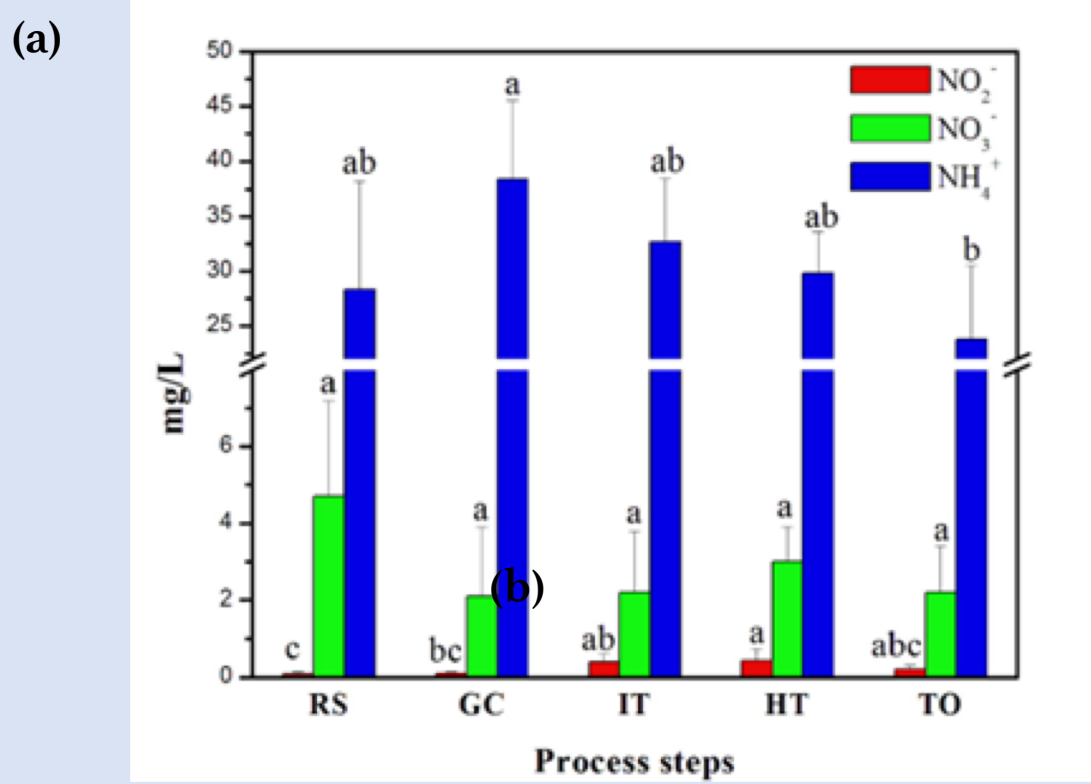
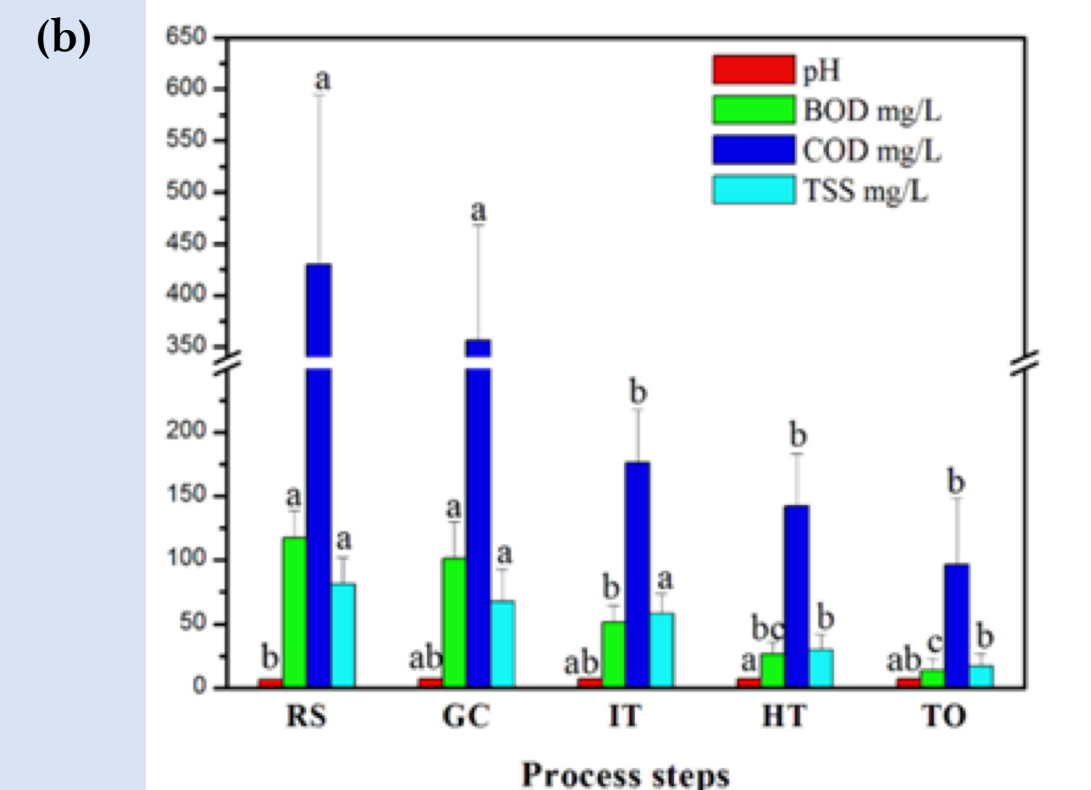


Fig. 7 Relationship among process steps with analyzed parameters (a) nitrate, nitrite and free ammonia, (b) pH, BOD, COD and TSS

4. Conclusions

- Overall process is effective in terms of BOD,COD and TSS
- For the treatment process pH was 6.68- 7.18 and EC was 590 - 710 µS/cm
- Process is effective in terms of Nitrate
- pH, BOD,COD,TSS have observed a significant different among process steps
- A strong negative correlation of pH was observed with BOD,COD,TSS m and a strong positive correlation with nitrite and nitrate
- A strong positive correlation was observed for BOD vs COD,TSS, while COD was observed a strong positive correlation with TSS
- The measured heavy metals of Zn, Cd, Cu, and Pb were less than the detectable levels at the end of the process
- All biochar doses (1,2,5 and 10 g/L) are acceptable in the sense of pH
- The EC range is existed in 567- 610 µS/cm for 5 and 10 g/L biochar doses
- In the means of cost effectiveness the best biochar dosage for nitrate reduction is 5 g/L at 48 hours
- The best BOD reduction is observed at 24 hours with 10 g/L
- Both doses 5 and 10 g/L at 24 hours can be used for the COD reduction

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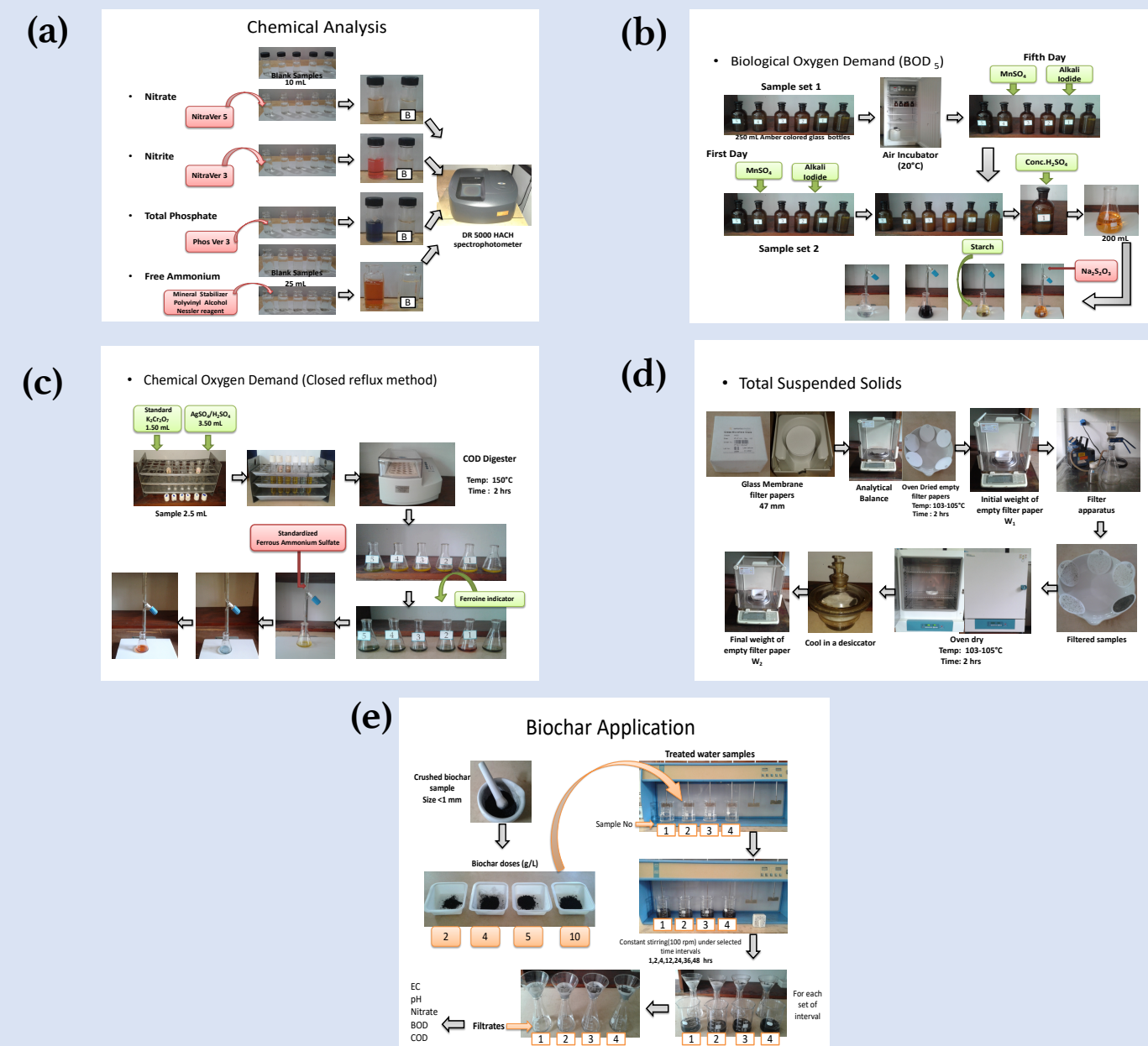


Fig. 5 Analysis procedure (a) Chemical analysis, (b) BOD, (c) COD, (d) TSS and (e) Biochar application for treated wastewater (HACH,2013 , APHA,1985)