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Evaluation of the efficiency of anaerobic baffled reactor under psychrophilic conditions for domestic wastewater treatment

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Abstract

Anaerobic baffled reactor is an efficient anaerobic treatment process for wastewater treatment. Temperature is one of the factors which affect the performance of anaerobic baffled reactor. In this study, efficiency of Anaerobic Baffled Reactor (ABR) was evaluated for the treatment of domestic wastewater at low temperature ranging from 5°C to 13°C. A laboratory scale reactor was constructed and was operated at 19 hours HRT, 23.15 mg COD/hour OLR, 1.47 L/hour flow rate at low temperature in an incubator. Under these operational conditions efficiency was evaluated for various waste water parameters using standard protocols. The results indicated 78, 36, 48 and 47% reduction in COD, total nitrogen, ammonium and sulphates respectively. Micronutrients were also added in Anaerobic Baffled Reactor in solution form, which includes Co, Ni, Cr, Fe, Zn, Mn and Cu in order to improve the microbial activity in ABR. Atomic absorption Spectrophotometry was used for the determination of micronutrients in inlet and outlet of Anaerobic Baffled Reactor throughout the experiments. Utilization efficiency of Ni, Co, Zn, Cr and Fe by microbes was 81, 92, 28, 28 and 95% respectively. Pathogen reduction efficiency of Anaerobic Baffled Reactor at low temperature was determined through Most Probable Number (MPN) which was not significant. It is concluded that anaerobic baffled reactor is a promising technology for wastewater treatment as primary treatment process.

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Introduction

Pollution and enhanced waste production is the problem of emerging world due to change in the life style of people. Wastewater is one of the major contributors of pollution and needs proper management and handling (Asano, 2007). It was estimated that total production of wastewater in Pakistan is 4.369 x 10^9 m^3/ year and 392,511 million gallons of industrial and municipal wastewater is discharged into the river which affects the water life. It also causes life-threatening diseases if this water is used for agricultural purposes. Only 8% of wastewater is treated in Pakistan through sedimentation ponds (Murtaza and Zia, 2012).

Wastewater treatment is carried out through three processes, which, includes physical, chemical and biological processes. Biological process is preferred over physical and chemical process because it is environmental friendly. In biological method, microorganisms play an important role in the degradation of organic matter. Biological method is further divided into two types which, includes aerobic and anaerobic biological processes. In aerobic process, microbes degrade the organic matter of wastewater in the presence of oxygen. The end product of aerobic process is carbon dioxide and biomass. Energy is required for aeration so this process is costly as compared to anaerobic process (Przywara *et al.*, 2014). In an anaerobic process, microbes in an anoxic condition degrade organic matter of wastewater. The end product of anaerobic process is treated water and biogas that is also used as energy source. Among anaerobic processes, anaerobic digestion is very effective method for treatment of wastewater. Anaerobic digestion consist of four steps which are hydrolysis, acidogenesis, acetogenesis and methanogenesis (Sebola *et al.*, 2013). In hydrolysis, obligate or facultative anaerobes hydrolyze the complex organic matter of wastewater into its subunits such as monosaccharides, amino acids, and long chain fatty acids by producing hydrolyzing enzymes, which includes cellulase, protease, lipase etc. (Veeken *et al.*, 2000). In acidogenesis, acidogenic microbes utilize the product of hydrolytic microbes as a substrate and convert it into organic acids which includes butyric acid, acetic acid, propionic acid etc. (Chang *et al.*, 2004). In acetogenesis, acetogenic microbes which are strict anaerobes consume the product of acidogenic microbes as a substrate and convert it into acetate, hydrogen and carbon dioxide (Karnholz *et al.*, 2002). In methanogenesis, which is the last stage of anaerobic digestion, methanogens utilize the product of acetogenic microbes as a substrate. Two types of methanogens are involved at this stage. Hydrogenotrophic methanogens consume the hydrogen and carbon dioxide whereas acetotrophic methanogens consume the acetate for production of biogas (Duin and McKee, 2008). So, anaerobic digestion for wastewater treatment is very beneficial because this process is easy to handle, cost effective as well as minimum sludge production(Weiland, 2010). Due to these benefits, anaerobic reactors are generally used for the treatment of wastewater (Zwain *et al.*, 2016).

Among anaerobic reactors, Anaerobic Baffled Reactor (ABR) is an efficient method for the treatment of wastewater. ABR was discovered in the 1981 by McCarty and coworkers at Stanford University. It is a modified septic tank that consist of vertical baffles in which wastewater moves in an up flow or down flow manner which increases the solid retention time due to which maximum contact occurs between wastewater and biomass. As a result, organic matter present in wastewater is degraded by microbes efficiently (Dama *et al.*, 2002). Anaerobic Baffled Reactor (ABR) consists of number of compartments ranging from two to ten. These compartments or partitions separate the bacterial groups of anaerobic digestion process from each other as a result of which microbes flourish under favorable conditions (Chen *et al.*, 2008). It was noticed that four chambered ABR is more effective in the treatment of wastewater at low temperature having removal efficiency of 90% TSS, 65% COD, 60% BOD_5 (Kennedy and Barriault, 2005). Compartmentalized design of ABR enhances the solid retention time (SRT). It prevents the risk of blockage as well as it is very stable to organic and hydraulic shocks. Initiation of anaerobic digestion process in ABR requires months because anaerobic microbes are slow growers and require time for establishment (McKeown *et al*., 2009). So, in order to initiate the anaerobic digestion process earlier in the reactor, the reactor should be inoculated with developed inoculum present in wastewater treatment plant. As it contains active anaerobic bacteria which can multiply rapidly and are able to adapt the conditions of the reactor (Ayaz *et al*., 2012). Inoculum to substrate ratio must be calculated before startup period of the reactor because it affects the biogas production rate. Anaerobic digestion process in ABR consist of hydrolysis, acidogenesis, acetogenesis and methanogenesis (Bodkhe, 2009).

Different factors affect the efficiency of ABR that include temperature, pH, micronutrients, ammonia as well as volatile fatty acids concentration. Temperature plays very important role in the treatment of wastewater because microbes which are involved in anaerobic digestion process produces enzymes which are affected by temperature due to which biogas production rate is also affected (Enright *et al*., 2005). In some parts of the world, temperature is low. So, at low temperature anaerobic digestion process occur through psychrophiles but biogas production is lower because reaction rate is slower at low temperature. Rate of hydrolysis is also lower at low temperature (Marin *et al*., 2010). Due to less liquid solid separation, solids will not settle down easily in the reactor as a result of which sludge wash out is observed at low temperature (Gupta, 2010). Solubility of gases (CH_4, CO_2 etc.) within wastewater also increases at low temperature. Due to solubility of carbon dioxide in wastewater, its pH drops to the significant level (Elmitwalli *et al*., 2001). But due to compartmentalized design of ABR, solid retention time increases due to which microbes have maximum time in order to degrade the organic matter of wastewater. So, ABR is very effective for treatment of wastewater at low temperature (Junyuan *et al*., 2011) . As psychrophiles are slow growers so in order to accelerate the startup period of the reactor, researchers use low temperature adapted mesophiles known as psychrotrophs as an inoculum. Odour, which is produced by ammonia and hydrogen sulfide in the reactor, is removed by the addition of micronutrients. It also stops the function of urease enzyme due to which urea, which, is, present in wastewater is not degraded into ammonia. Sludge which was accumulated during wastewater treatment is reduced up to 80% by the addition of micronutrients (Kampe *et al*., 2018).

In order to improve the activity of microbes involved in an anaerobic digestion process, some important nutrients in small amount known as micronutrients are required for its maximum efficiency. If these micronutrients are added in ABR for wastewater treatment, the biogas production rises to a significant level (Cavaleiro *et al*., 2008). Micronutrients are provided to microbes in specific manner like complex formation with organometallic compounds increases its availability to microbes (Barber and Stuckey, 2000). Fats, oil and grease are also removed from wastewater by the addition of micronutrients. Sludge which is accumulated in the reactor is also reduced by the addition of micronutrients (Demirel and Scherer, 2011).

Efficiency of anaerobic digestion process also depends upon ammonia. Ammonia is produced in the reactor by the degradation of nitrogen containing compounds by microbes. Ammonia up to 200 mg/L in wastewater is very beneficial for growth of microbes (Vidal *et al*., 2000). But when its concentration exceeds from the limit then it stops the growth of methanogens because they are very sensitive to ammonia due to which anaerobic digestion process is disturbed. But its toxicity is reduced by addition of some ions such as calcium, magnesium and sodium ions, which has antagonistic behavior. It means that toxicity of ammonia is reduced by the addition of these ions (Inanc *et al*., 2000).

The aim of the present research study was the evaluation of the performance of Anaerobic Baffled Reactor (ABR) under psychrophilic conditions for domestic wastewater treatment. For this purpose a lab scale ABR was designed and run at low temperature. Different wastewater parameters like, COD, total nitrogen, ammonia and sulphates removal were monitored. Pathogen reduction and utilization of micronutrients were also evaluated.

Materials and methods

In the present study, a Lab scale Anaerobic Baffled Reactor was constructed and its efficiency was evaluated for domestic wastewater treatment, coming from the residential area of Quaid-i-Azam University, Islamabad at low temperature.

Inoculum development

Inoculum was developed from fresh cattle manure collected from local farms located near Quaid-i-Azam University, Islamabad. Before the development of inoculum, total solids and volatile solids of cattle manure were analyzed separately in triplicates by using standard methods of 2540B (APHA, 2005) and 2540G (APHA, 2005) respectively.

The percentage of volatile solids was 84.4% and for the development of inoculum, 300 to 400 g of organic matter in manure must be present per liter of water so that microbes utilize it as a source of energy. So, 500 g of manure was dissolved in 1.5 liter of tap water to make slurry, which contained at least 400 to 450 g of organic matter.

This slurry was pour into the bottles having 2.5 liter volume. Nitrogen sparging was done for the development of anaerobic conditions in the bottles having manure mixture or slurry. Gas collection bags were attached with bottles to check activity. These bottles then were incubated at environmental temperature for 25 days. During incubation period, gas was formed which was collected in gas collection bags and it was an indication that inoculum is fully developed.

Inoculum to substrate ratio was adjusted by calculating the COD of inoculum as well as wastewater (substrate) by COD kits (Merck) in a range of 25-1500 mg/L. Volume of the reactor was 28 L so, according to adjusted ratio (1:4), 5L of inoculum and 20 L of wastewater was added in the reactor.

Designing of the Lab scale reactor (ABR)

Lab scale Anaerobic Baffled Reactor was constructed from clear soda glass. It has 28 L volume.

Its dimensions consist of 58 cm x 20 cm x 40 cm (LxWxH). The whole reactor is divided into four portions or chambers (Fig. 1).

Reactor setup

Reactor was closed with lid and sealed by using silicon. One sampling hole in each compartment was present on the top of the lid through which tubes were inserted for sampling. Tubes were inserted in such a way that half of the tube was dipped in the water sample and other half of the tube was on the top of the lid through which syringe was attached for sampling. One of the tubes was attached with gas collection bag. Inlet and outlet of the reactor was attached with pipes. Anaerobic conditions were developed in the reactor by flushing the reactor with nitrogen gas.

Startup phase

Reactor was placed in the incubator at low temperature ranging from 3˚C to 13˚C and maintained at steady state conditions for 1 month for the establishment and adaptation of microflora at low temperature. After 1 month of incubation, reactor was fed continuously with domestic wastewater through inlet pipe. Reactor was operated at 19 hours HRT, 23.15 mg COD/hour OLR, 1.47 L/hour flow rate. Samples were collected every week for analyses and reactor temperate was also monitored (Table 1).

Addition of micronutrient solution

Micronutrient solution (5 mL) was added into the reactor in continuous state on daily basis for first 20 days, 10 mL of each of the solution for next 20 days and 15 mL for last 20 days. Each of the micronutrient solutions was prepared by adding following concentration of micronutrients per liter of distilled water (Kim *et al.*, 2002).

$FeCl_2.4H_2O$...............................35.6 mg/L
$ZnCl_2$...2.08 mg/L
$NiCl_2.6H_2O$................................4.05 mg/L
$CoCl_2.6H_2O$...............................4.04 mg/L
$MnCl_2.4H_2O$...............................3.61mg/L

When reactor was in continuous state, temperature of the incubator as well as the reactor was noted down on daily basis in order to evaluate its impact on efficiency of the reactor. Almost 100 to 200 mL of water sample was taken in a plastic bottle from inlet and outlet of the reactor on daily basis for physicochemical analysis. Samples were stored at 4°C for further analysis. Water samples were also taken from each portion of the reactor along with inlet, outlet influent and effluent in a 250 mL plastic bottles after every week. These samples were stored in refrigerator at 4°C for further analysis.

Physico-chemical analysis of wastewater

Physico-chemical analysis of wastewater was carried out by determining different parameters i.e. pH was determined by digital meters while electrical conductivity (EC) and salinity were measured by PCS Multi test meter. Chemical oxygen demand (COD) was determined by kit method (Merck, Germany). Standard methods 1540-C, 4500-P and 0375 Barium chrometery were used to estimate total dissolved solids (TDS), phosphates and sulfates concentrations respectively in water samples before and after treatment while ammonia nitrogen was determined by using Kit method (APHA, 2005). Spectraquant Merck Co. was used for analyses.

Trace metals analysis

Trace metals from the sample was analyzed by Atomic Absorption Spectrometer using Acetylene flame. Samples were pre-treated through acid digestion method. 2mL sample was pipetted into test tube 10 mL Nitric Acid (65%) and 1mLperchloric acid was added. Samples were kept overnight for the digestion. After digestion, they were heated at hot plate for 2-3 seconds until the white fumes appeared. Then 2 mL of the digested sample was diluted with distilled water to gain 25 mL total volume. Afterward they were analyzed using Agilent Atomic absorption spectrophotometer with respective electrode.

Microbiological analysis

Pathogen reduction tests were performed by taking the sample from inlet and outlet of the reactor. Pathogen reduction tests include Most Probable Number (MPN).

Most probable number test (MPN Index) for faecal coliforms

Most probable number test was performed according to Bergey's Manual for the examination and estimation of fecal coliforms within water samples. Three sets of test tubes (each set contain 3 test tubes filled with lactose broth along with upside-down Durham tubes) were inoculated with water sample and then incubated at 35°C for 48 hrs. After incubation, test tubes with gas bubbles in Durham tube were considered positive, which would be further streaked on nutrient agar plates (NA) and then incubate at 37°C for 24 hrs. The positive isolates of bacteria were confirmed by general microscopy technique. Number of tubes that would be considered positive for gas production was measured against standard dilution table for MPN-index.

Results

Physico-chemical analysis of domestic wastewater before and after treatment in ABR

In this study, lab scale Anaerobic Baffled Reactor was constructed and its efficiency was evaluated for domestic wastewater treatment, coming from the residential area of Quaid-i-Azam University, Islamabad. The results indicated that the pH of water was from 7.3 to 7.9 (Fig. 2). Maximum reduction of EC in treated water samples was about 28% as shown in Fig.3. According to WHO, the range of TDS in water are less than 1000 mg/L. Treated and untreated water samples of Anaerobic Baffled Reactor (ABR) showed TDS within the range as described by WHO. Maximum reduction of TDS in treated water samples was about 30% (Fig.4). Salinity of treated and untreated water samples was also determined like other parameters and maximum reduction of salinity in treated water samples was about 29 % (Fig.5).

Maximum reduction of COD in treated water samples was about 83% (Fig.6). Maximum reduction efficiency of ABR for total nitrogen is about 36% (Fig.7). According to Pak-EPA rules, up to 250 mg/l of sulphates are allowed in water. Reduction efficiency of ABR for sulphates was about 47% (Fig.8). Water samples were also analyzed for ammonium and maximum reduction for ammonium in treated water samples was about 48% (Fig.9).

Table 1. Sample taken after every week of reactor establishment and average temperature of the incubator.

Sample No.	Week	Temp.
1	Week 1	12°C
2	Week 2	10°C
3	Week5	11°C
4	Week 6	8°C
5*	Week 7	27°C
6*	Week 10	24°C
7	Week 12	16°C
8	Week 13	7°C
9	Week 14	9°C
10	Week 15	6°C
11	Week 17	5°C

*Incubator temperature rose due to electricity failure.

Table 2. MPN test for the presence or absence of fecal coliform in inlet and outlet wastewater sample.

Samples	Inlet waste water sample(untreated)	Outlet waste water sample(treated)
Week 1	>1100 MPN INDEX/100 ml	1100 MPN INDEX/100 ml
Week 2	>1100 MPN INDEX/100 ml	>1100 MPN INDEX/100ml
Week5	>1100 MPN INDEX/100ml	1100 MPN INDEX/100 ml
Week 6	>1100 MPN INDEX/100 ml	150 MPN INDEX/100 ml
Week 7	>1100 MPN INDEX/100 ml	>1100 MPN INDEX/100 ml
Week 10	>1100 MPN INDEX/100 ml	210 MPN INDEX/100 ml
Week 12	>1100 MPN INDEX/100 ml	460 MPN INDEX/100 ml
Week 13	>1100 MPN INDEX/100 ml	1100 MPN INDEX/100 ml
Week 14	>1100 MPN INDEX/100 ml	20 MPN INDEX/100 ml
Week 15	>1100 MPN INDEX/100 ml	>1100 MPN INDEX/100 ml
Week 17	>1100 MPN INDEX/100 ml	1100 MPN INDEX/100 ml

Analysis of trace metals in domestic wastewater before and after treatment in ABR

Trace element solution was added in the reactor to enhance the efficiency and utilization of different metals were analyzed. The results showed that maximum reduction of iron in treated water samples was about 95% and 25% reduction in chromium was observed. While percentage reduction of cobolt in treated water samples was about 92%. Zinc was also analyzed in treated and untreated water samples. Maximum reduction of zinc in treated water samples was about 28%. Like other trace metals, nickel was also analyzed in water samples and maximum reduction of nickel in treated water samples was about 81% (Fig.10).

Analysis of pathogen reduction of untreated and treated domestic wastewater through Anaerobic Baffled Reactor

The experiment of Most Probable Number (MPN) was conducted by using lactose broth as a medium which confirms the presence or absence of fecal coliforms in the water sample. The presumptive and confirmatory tests were also positive for MPN positive tubes. The data showed that MPN reduction was not observed in the initial week samples while reduction was observed in 5^{th}, 10^{th} and 11^{th} week.

Maximum reduction to 20 MPN/100 mL in 20^{th} sample (Table 2).

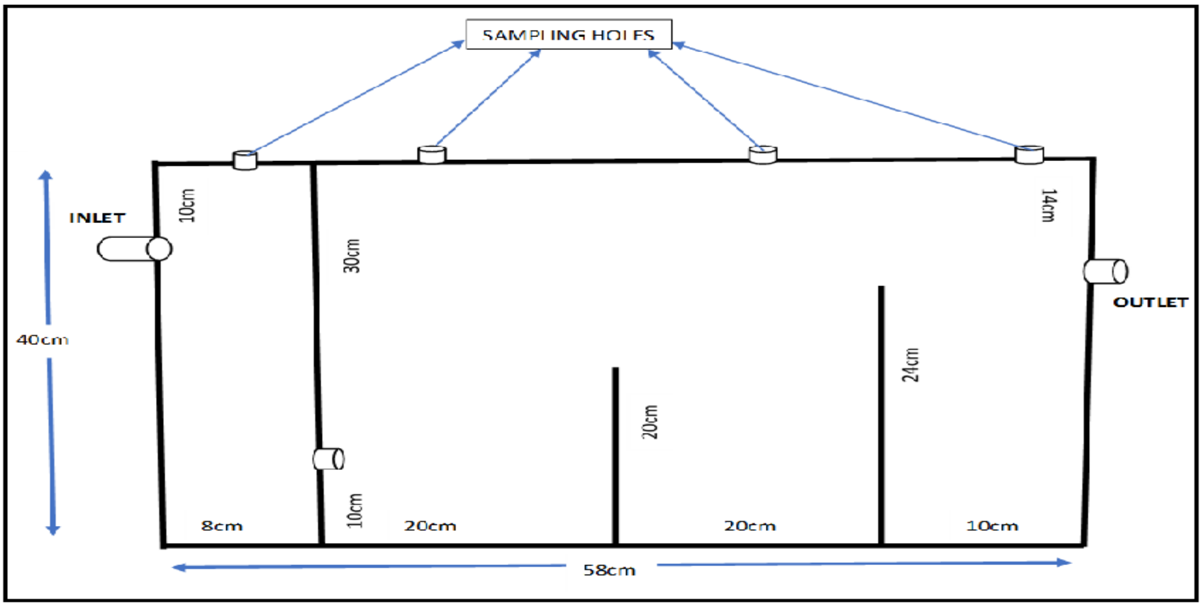

Fig. 1. Schematic Diagram of Lab scale Anaerobic Baffled Reactor (ABR).

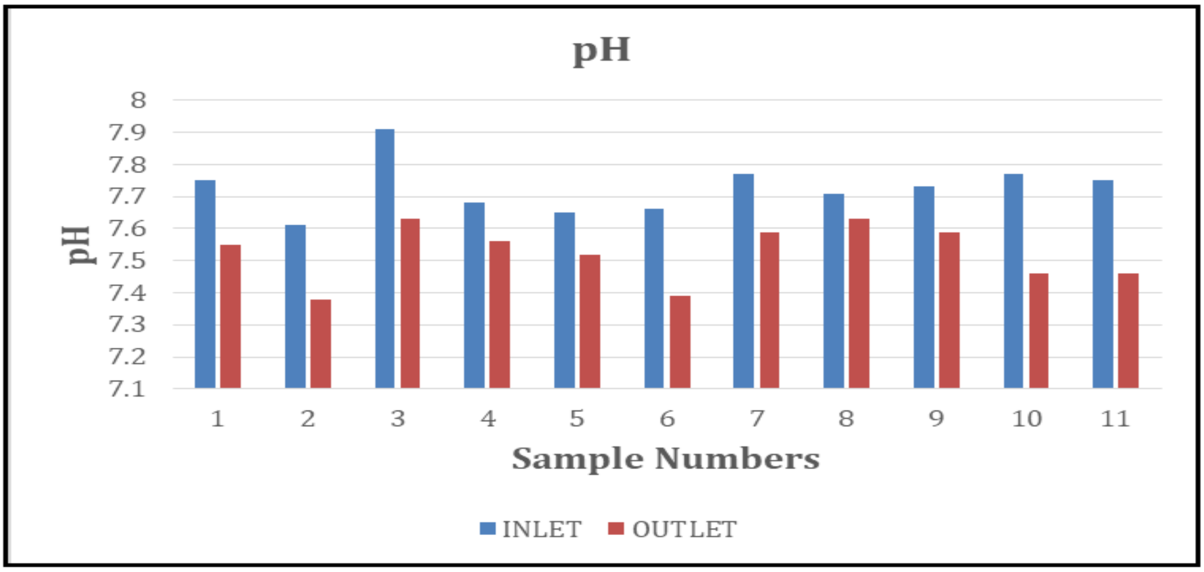

Fig. 2. Change in pH value of domestic wastewater during treatment in ABR.

Discussion

The aim of the present research study is the evaluation of the performance of Anaerobic Baffled Reactor (ABR) under psychrophilic conditions for domestic wastewater treatment. Reactor was placed at low temperature ranging from 3°C to 13°C and incubated at steady state conditions for 1 month for the establishment and adaptation of microflora at low temperature. At the selected operational conditions, percentage reduction of COD, soluble COD, total nitrogen, ammonium and sulphates was 78%, 69%, 36%, 48% and 47% respectively (Fig 6-9). At low temperature this is significant reduction. One of the study was conducted at low temperature by using Anaerobic Baffled Reactor operated at 20 hours HRT at 35°C, 96% reduction in COD was observed because when temperature increases, reaction rate also increases (Nachaiyasit and Stuckey, 1997).

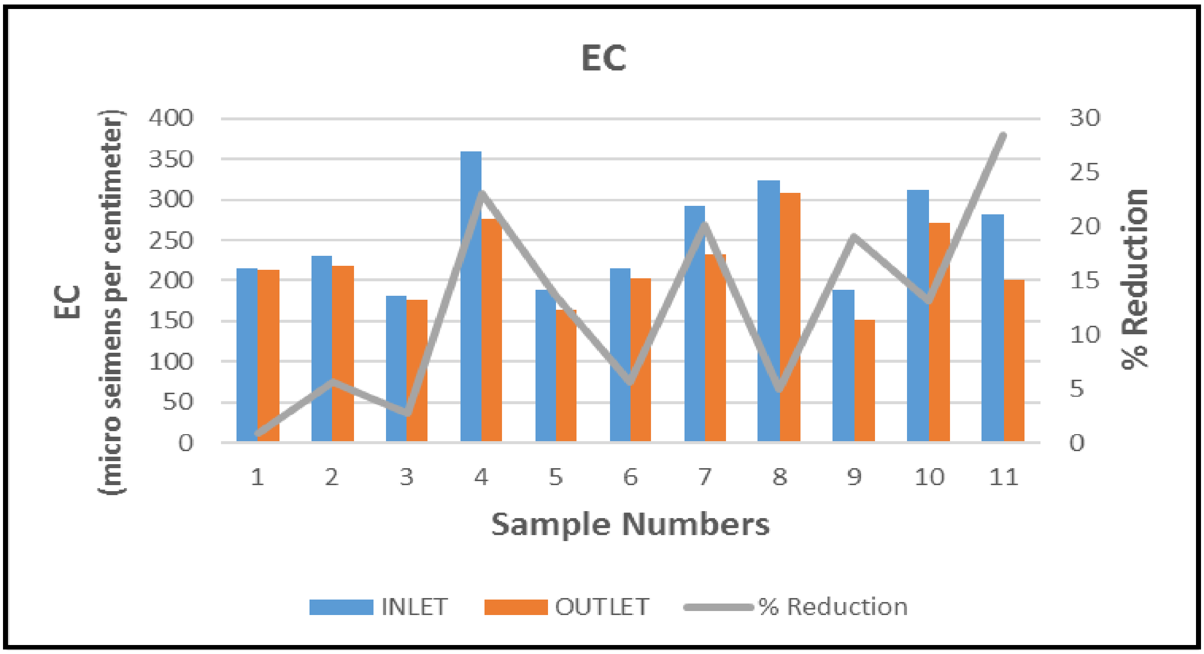

Fig. 3. EC of domestic wastewater before and after treatment in ABR.

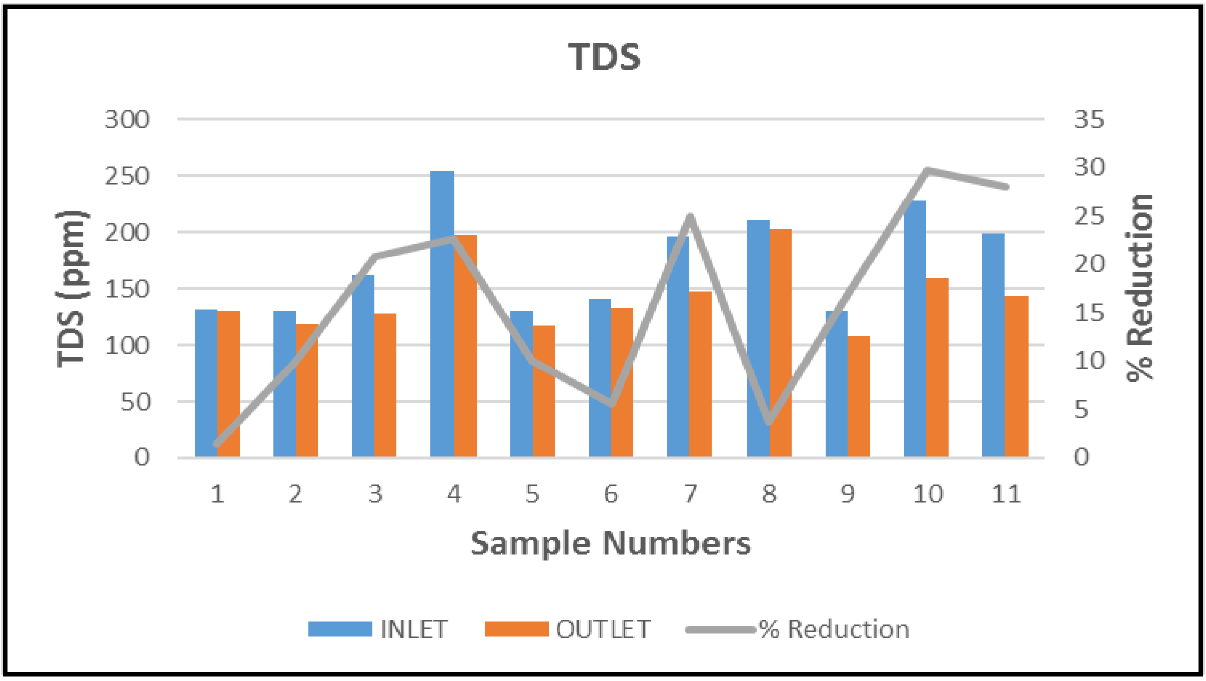

Fig. 4. TDS of domestic wastewater before and after treatment in ABR.

Another study was conducted at 18 hours HRT, it was observed that there was 80% reduction of COD (Motteran *et al.*, 2013). This result is quite similar to our study which was conducted at 19 hours HRT. In another study, the total nitrogen removal efficiency of ABR while treating municipal wastewater was 72% at

1 day HRT (Bodkhe, 2009). In the study, nitrogen removal efficiency was 36% (Fig 7), the reason of variation may be 19 hours HRT. In another research study conducted by Bodik *et al.*, 2000 by using Anaerobic Baffled Reactor for the treatment of wastewater, it was noticed that reduction efficiency of ammonium was 46.4% (Bodik *et al.*, 2000) while in the present study showed percentage reduction of ammonium was 48%.

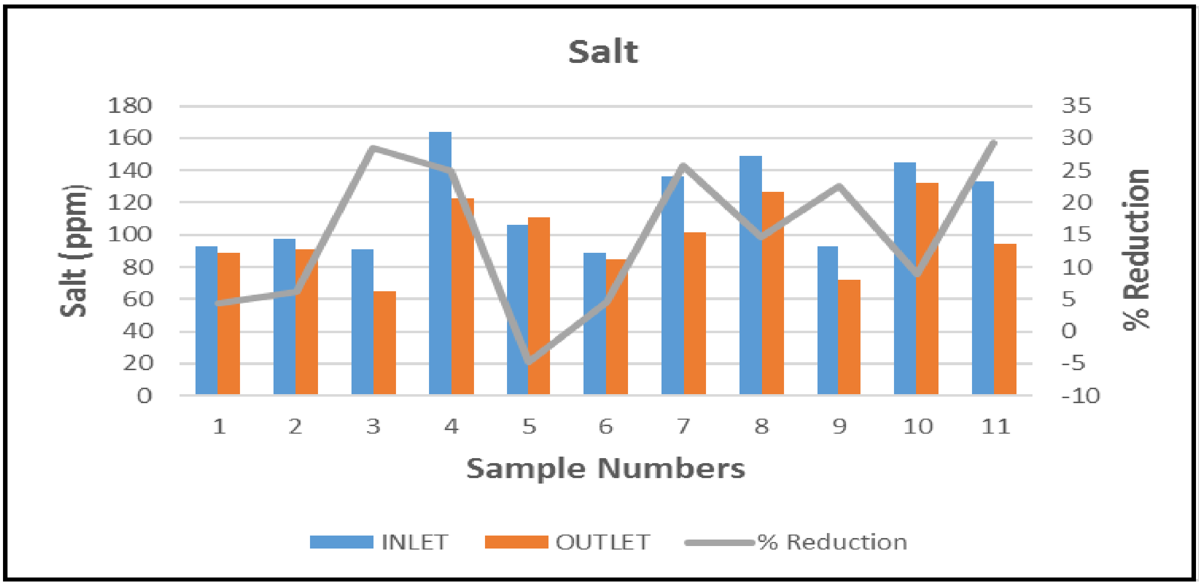

Fig. 5. Salinity of domestic wastewater before and after treatment in ABR.

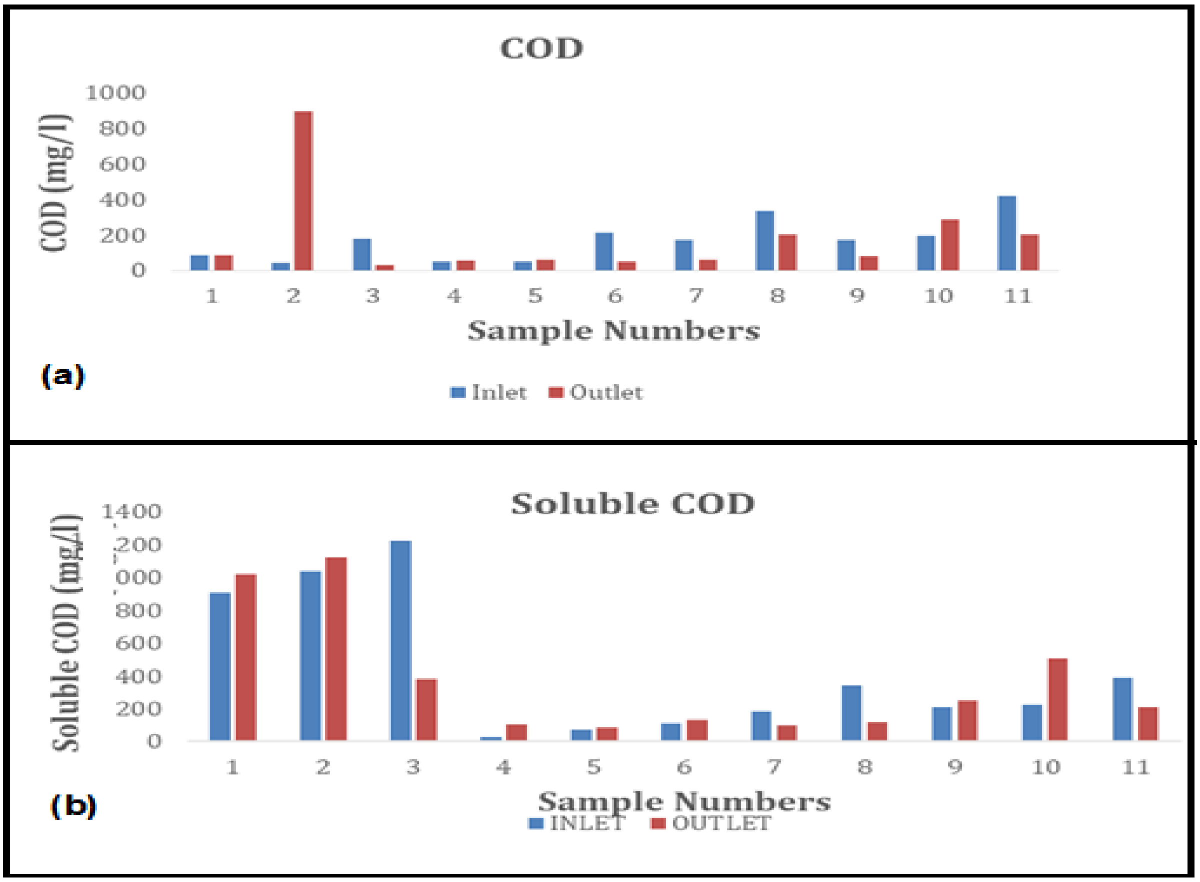

Fig. 6. Change in COD (a) and Soluble COD (b) concentration of samples during domestic wastewater treatment in lab scale ABR.

In 2009, one of research was conducted at 35°C by using Anaerobic Baffled Reactor for the treatment of acidic wastewater and it was observed that there was 20%, 23%, 25% and 30% reduction of sulphates from compartment 1 to compartment 4 and its reduction rises to 80% at the end of period (Bayrakdar *et al.*, 2009). In this research, sulphate reduction efficiency was 47% because reactor was operated at low temperature due to which reaction rate may be reduced.

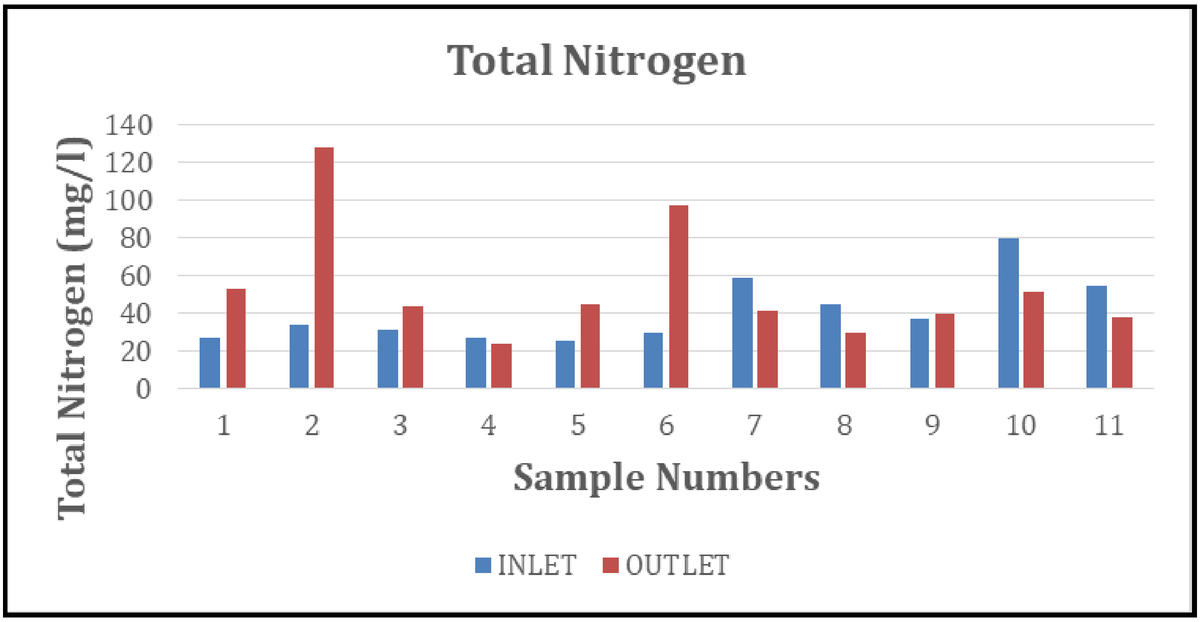

Fig. 7. Change in total nitrogen concentration of samples during domestic wastewater treatment in lab scale ABR.

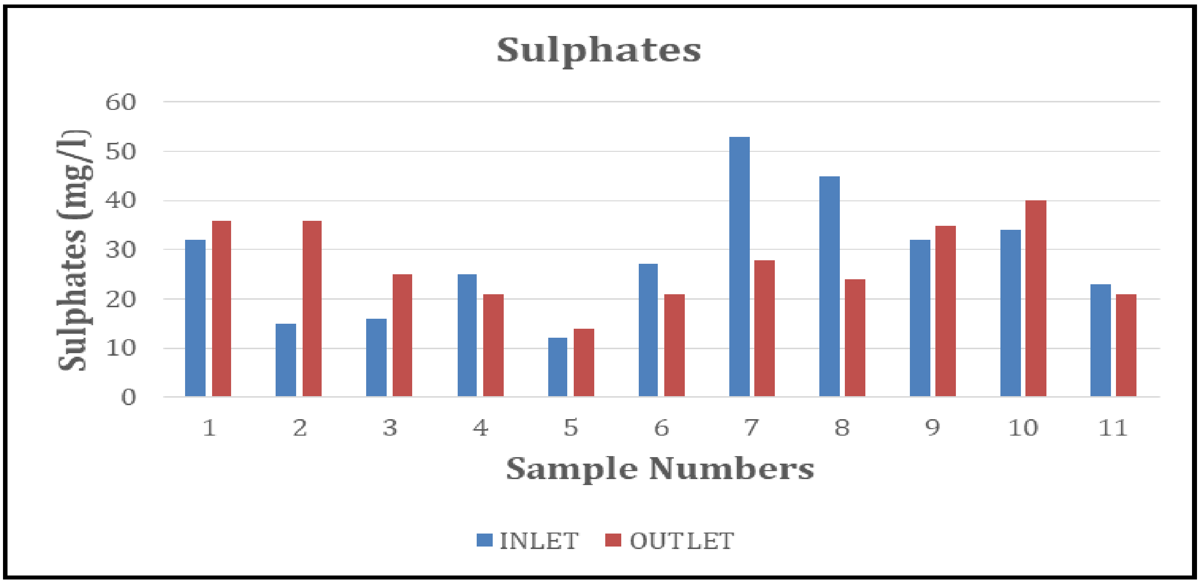

Fig. 8. Change in total nitrogen concentration of samples during domestic wastewater treatment in lab scale ABR.

Microorganisms require some nutrients such as Cr, Co, Mn, Fe, Zn, Ni etc. in trace amount for growth and activity (Aldin *et al.*, 2011). In this study, Anaerobic Baffled Reactor was supplemented with micronutrients in solution form, which includes Ni, Co, Zn, Cr, Fe, Cu, Mn. The percentage reduction of these micronutrients was 81%, 92%, 28%, 28% and 95% respectively (Fig 10). It means that respective percentage of micronutrients was effectively consumed by microbes, which results in better activity of microbes within the reactor.

In 2011, it was noticed that addition of Co, Ni and Mg enhances the enzymatic activity of microbes (Bao *et al.*, 2011). Another study was conducted in 2012 and it was noticed that addition of Co, Ni and Fe enhances the transformation of acetate and propionate due to which methane production rises (Karlsson *et al.*, 2012).

In 2014, it was observed that addition of Ni, Cu and Zn also enhances metabolic activity of microbes due to which biogas production also rises (Okeh *et al.*, 2014). Degradation of proteins, carbohydrates, lipids were enhanced by the addition of Fe, Co, Ni and the rate of hydrolysis was 21%, 45% and 8% respectively (Kim *et al.*, 2002).

It was observed that addition of micronutrients in the water sample reduces the production of hydrogen sulphide and ammonia by anaerobic microbes.

It was also noticed in the same study that micronutrients block the active site of urease enzyme due to which urea is not converted into volatile ammonia and as a result, there was 75% reduction of volatile ammonia in water sample (Maat, 2015).

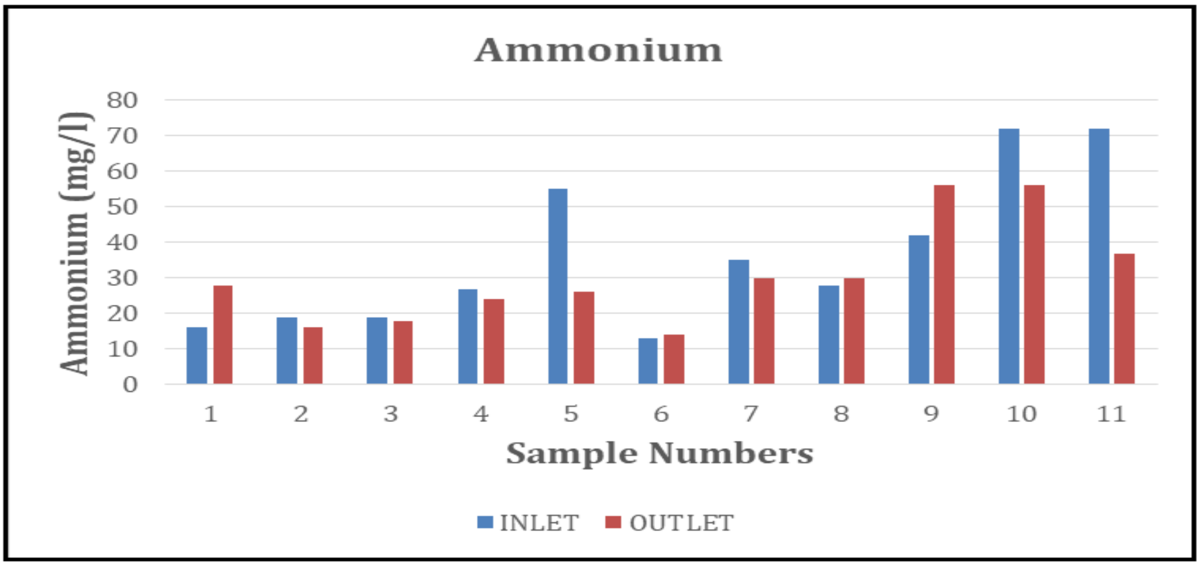

Fig. 9. Change in ammonium concentration of samples during domestic wastewater treatment in lab scale ABR.

Pathogen reduction efficiency of ABR was determined through two methods which were Most Probable Number (MPN) which so much significant (Table 2).

In another research study conducted by Foxon *et al.*, 2001, it was analyzed that pathogen reduction efficiency was determined through CFU and it was approximately 68%. It means that it is less than a 1 log which was also not as much significant (Foxon *et al.*, 2001).

In this research work, wastewater was treated through anaerobic digestion process by using Anaerobic Baffled Reactor. As we know that anaerobic digestion process consists of hydrolysis, acidogenesis, acetogenesis and methanogenesis. Enzymatic activity of hydrolytic microbes for amylase, protease and lipase are examined and it shows that these microbes are positive for amylase, lipase activity and it showed negative results for protease activity (results not shown).

In 2009, enzymatic activity of hydrolytic microbes were analyzed at 37°C and it was noticed that these microbes showed positive results for amylase, protease and lipase activity because when temperature rises, metabolic activity of microbes also rises (Borla *et al.*, 2010).

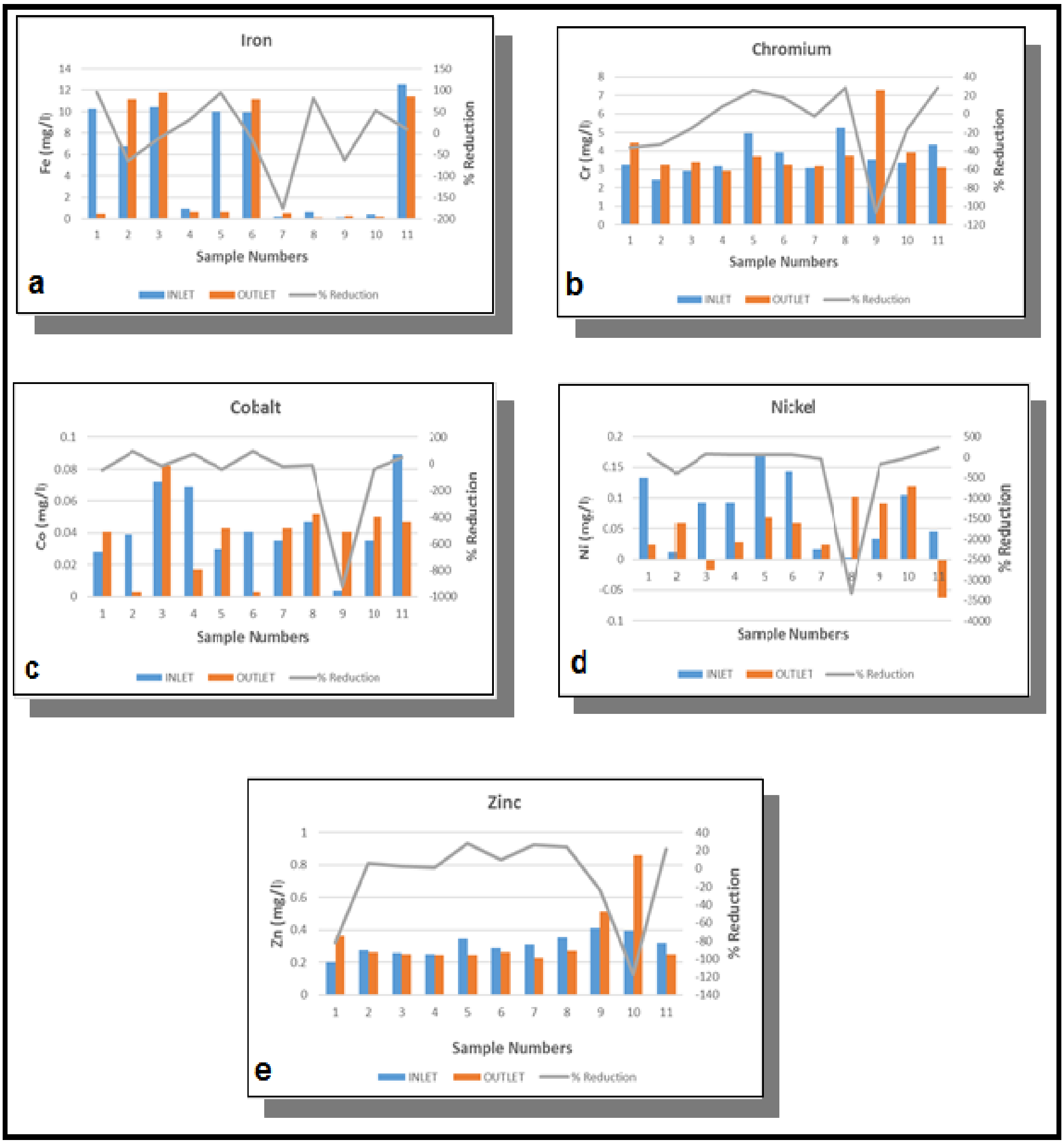

Fig. 10. Concentrations of different metal ions in the wastewater a, iron; b, chromium,; c, cobalt; d, nickel and e, zinc.

Conclusion

Anaerobic Baffled Reactor (ABR) is proved to be very efficient in treating domestic wastewater under psychrophilic conditions. The inoculum developed at environmental temperature was not too much sensitive to temperature shocks even after incubated at psychrophilic temperature in Anaerobic Baffled Reactor (ABR). The compartmentalized design of Anaerobic Baffled Reactor (ABR) allows various microbial groups to flourish under suitable conditions. As a result, domestic wastewater is effectively treated under psychrophilic conditions. At 19 hours HRT, the contact time between microbes and substrate (wastewater) increases which results in better degradation of organic matter present in wastewater. Addition of micronutrients solution in Anaerobic Baffled Reactor (ABR) enhanced the microbial activity due to which percentage reduction of COD, soluble COD, total nitrogen, ammonium and sulphates were 78%, 69%, 36%, 48% and 47% respectively.

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