Table 1: Effect of carbon sources (%) on cellulase production (U/mL) by *A. niger*.

Conc. (%)			0.5	1.0	1.5	2.0	2.5	3.0
Different carbon sources	Glucose	1	0.41 ± 0.02	1.88 ± 0.07	1.32 ± 0.04	0.91 ± 0.05	0.54 ± 0.03	0.37 ± 0.02
		2	0.26 ± 0.02	1.61 ± 0.05	1.11 ± 0.03	0.82 ± 0.04	0.51 ± 0.05	0.29 ± 0.03
		3	0.21 ± 0.02	1.90 ± 0.05	1.39 ± 0.04	0.71 ± 0.04	0.48 ± 0.03	0.20 ± 0.02
	Maltose	1	0.09 ± 0.02	1.13 ± 0.05	0.91 ± 0.04	0.76 ± 0.04	0.39 ± 0.03	0.13 ± 0.03
		2	0.18 ± 0.02	1.37 ± 0.06	1.24 ± 0.04	0.64 ± 0.05	0.34 ± 0.03	0.22 ± 0.02
		3	0.41 ± 0.02	1.84 ± 0.06	1.71 ± 0.04	1.11 ± 0.04	0.69 ± 0.02	0.40 ± 0.02
	Sucrose	1	0.49 ± 0.02	2.07 ± 0.05	1.55 ± 0.05	0.73 ± 0.04	0.39 ± 0.04	0.18 ± 0.02
		2	0.11 ± 0.06	1.81 ± 0.03	1.11 ± 0.04	0.76 ± 0.04	0.35 ± 0.03	0.24 ± 0.02
		3	0.22 ± 0.02	1.76 ± 0.05	1.51 ± 0.04	0.82 ± 0.04	0.27 ± 0.02	0.10 ± 0.03
	Cellulose	1	0.23 ± 0.02	1.97 ± 0.07	1.64 ± 0.05	0.77 ± 0.04	0.42 ± 0.04	0.26 ± 0.03
		2	0.15 ± 0.02	1.67 ± 0.03	0.73 ± 0.04	0.54 ± 0.04	0.29 ± 0.02	0.11 ± 0.05
		3	0.21 ± 0.02	2.31 ± 0.07	0.76 ± 0.04	0.61 ± 0.04	0.38 ± 0.02	0.29 ± 0.02
	Carboxymethyl cellulose	1	0.19 ± 0.02	1.88 ± 0.05	1.01 ± 0.04	0.73 ± 0.04	0.48 ± 0.03	0.31 ± 0.02
		2	0.15 ± 0.02	1.10 ± 0.05	1.01 ± 0.04	0.51 ± 0.04	0.34 ± 0.03	0.19 ± 0.03
		3	0.33 ± 0.02	2.09 ± 0.07	1.27 ± 0.04	0.81 ± 0.05	0.57 ± 0.02	0.23 ± 0.02

1-FPase, 2-CMCase & 3-β-glucosidase.

Table 2: Effect of nitrogen sources (%) on cellulase production (U/mL) by *A. niger*.

Conc.			0.5	1.0	1.5	2.0	2.5	3.0
Different nitrogen sources	Peptone	1	0.19 ± 0.02	1.78 ± 0.06	1.27 ± 0.04	0.87 ± 0.04	0.61 ± 0.03	0.41 ± 0.02
		2	0.06 ± 0.02	1.44 ± 0.05	1.08 ± 0.04	0.62 ± 0.04	0.43 ± 0.03	0.38 ± 0.03
		3	0.27 ± 0.02	1.97 ± 0.05	1.61 ± 0.05	0.97 ± 0.04	0.51 ± 0.03	0.43 ± 0.05
	Yeast extract	1	0.16 ± 0.02	1.71 ± 0.07	1.43 ± 0.05	0.95 ± 0.04	0.69 ± 0.02	0.53 ± 0.03
		2	0.09 ± 0.02	1.68 ± 0.03	1.34 ± 0.04	0.72 ± 0.04	0.56 ± 0.07	0.33 ± 0.05
		3	0.31 ± 0.02	1.89 ± 0.05	1.43 ± 0.04	1.05 ± 0.04	0.73 ± 0.02	0.51 ± 0.04
	Beef extract	1	0.64 ± 0.02	1.78 ± 0.05	1.27 ± 0.04	0.87 ± 0.04	0.61 ± 0.03	0.41 ± 0.05
		2	0.16 ± 0.02	1.54 ± 0.07	1.08 ± 0.04	0.62 ± 0.05	0.43 ± 0.03	0.38 ± 0.02
		3	0.27 ± 0.02	1.97 ± 0.03	1.61 ± 0.04	0.97 ± 0.04	0.51 ± 0.07	0.43 ± 0.05
	Ammonium nitrate	1	0.09 ± 0.02	1.02 ± 0.04	0.83 ± 0.03	0.43 ± 0.04	0.37 ± 0.02	0.20 ± 0.02
		2	0.08 ± 0.02	0.97 ± 0.03	0.73 ± 0.04	0.54 ± 0.04	0.29 ± 0.07	0.11 ± 0.05
		3	0.18 ± 0.02	0.99 ± 0.03	0.84 ± 0.04	0.63 ± 0.04	0.41 ± 0.07	0.32 ± 0.05
	Sodium nitrate	1	0.12 ± 0.02	1.62 ± 0.05	1.03 ± 0.04	0.89 ± 0.04	0.55 ± 0.02	0.47 ± 0.05
		2	0.10 ± 0.02	1.39 ± 0.06	1.01 ± 0.04	0.72 ± 0.04	0.44 ± 0.03	0.21 ± 0.02
		3	0.41 ± 0.02	1.84 ± 0.05	1.21 ± 0.04	0.79 ± 0.05	0.61 ± 0.04	0.33 ± 0.02

1-FPase, 2-CMCase & 3-β-glucosidase.

3.2.5. Effect of Nitrogen Sources on Enzyme Production. The effect of different nitrogen sources on the production of cellulase enzyme by *A. niger* and *Trichoderma* sp. was investigated. The nitrogen sources tested ranged from 0.5 to 3.0% (w/v) peptone, beef extract, yeast extract, ammonium nitrate, and sodium nitrate. The results in Table 2 showed that a concentration of 1.0% peptone, beef extract, and yeast extract led to maximum production of cellulase enzyme. Among different nitrogen sources, the highest cellulase production (exoglucanase (1.78 U/mL), endoglucanase (1.44 U/mL), and β-glucosidase (1.97 U/mL)) was reported from 1.0% peptone and production decreased significantly below and above this concentration by *A. niger*. Peptone produced maximum cellulase followed by ammonium nitrate and beef extract while yeast extract and sodium nitrate produced almost same, lesser, quantity of cellulase by *A. niger* while nitrogen sources had a marked effect on enzyme produced by *Trichoderma* sp. The maximum enzyme activities were obtained with yeast extract (1.0%) which brought about an improvement in all the three cellulase components, including exoglucanase (2.40 U/mL), endoglucanase (2.28 U/mL), and β-glucosidase (1.99 U/mL), where peptone also produces the second most cellulase producing nitrogen source by *Trichoderma* sp. (Table 4). It was reported that good cellulase yield can be obtained with ammonium compound as the nitrogen source. Though the addition of organic nitrogen sources such as beef extract and peptone resulted in increased growth and enzyme

Table 3: Effect of carbon sources (%) on cellulase production (U/mL) by *Trichoderma* sp.

Conc. (%)			0.5	1.0	1.5	2.0	2.5	3.0
Different carbon sources	Glucose	1	0.68 ± 0.04	2.31 ± 0.08	1.71 ± 0.06	0.97 ± 0.05	0.62 ± 0.04	0.26 ± 0.02
		2	0.49 ± 0.03	1.93 ± 0.07	1.43 ± 0.05	0.98 ± 0.04	0.74 ± 0.04	0.34 ± 0.03
		3	0.41 ± 0.02	1.91 ± 0.09	1.67 ± 0.07	0.91 ± 0.05	0.55 ± 0.04	0.37 ± 0.03
	Maltose	1	0.44 ± 0.05	1.89 ± 0.08	1.61 ± 0.08	1.26 ± 0.06	0.81 ± 0.05	0.63 ± 0.04
		2	0.35 ± 0.04	1.91 ± 0.07	1.46 ± 0.05	0.88 ± 0.05	0.53 ± 0.04	0.32 ± 0.03
		3	0.47 ± 0.05	1.90 ± 0.08	1.63 ± 0.06	1.10 ± 0.05	0.72 ± 0.04	0.39 ± 0.03
	Sucrose	1	0.67 ± 0.05	2.68 ± 0.07	2.21 ± 0.08	1.55 ± 0.05	0.84 ± 0.04	0.44 ± 0.03
		2	0.50 ± 0.06	2.17 ± 0.07	1.51 ± 0.06	0.86 ± 0.05	0.64 ± 0.04	0.31 ± 0.03
		3	0.42 ± 0.04	2.06 ± 0.08	1.51 ± 0.08	0.90 ± 0.06	0.74 ± 0.05	0.31 ± 0.04
	Cellulose	1	0.41 ± 0.05	1.99 ± 0.08	1.71 ± 0.07	1.11 ± 0.07	0.83 ± 0.06	0.56 ± 0.04
		2	0.70 ± 0.06	1.89 ± 0.07	1.33 ± 0.07	0.94 ± 0.06	0.68 ± 0.05	0.55 ± 0.04
		3	0.35 ± 0.04	2.08 ± 0.07	1.81 ± 0.07	0.92 ± 0.06	0.71 ± 0.05	0.59 ± 0.04
	Carboxymethyl cellulose	1	0.41 ± 0.03	1.94 ± 0.06	1.71 ± 0.05	0.63 ± 0.05	0.42 ± 0.04	0.32 ± 0.03
		2	0.37 ± 0.04	1.72 ± 0.05	1.63 ± 0.06	0.85 ± 0.05	0.64 ± 0.04	0.38 ± 0.04
		3	0.41 ± 0.05	1.88 ± 0.07	1.73 ± 0.08	1.41 ± 0.06	0.86 ± 0.05	0.43 ± 0.04

1-FPase, 2-CMCase & 3-β-glucosidase.

Table 4: Effect of nitrogen sources (%) on cellulase production (U/mL) by *Trichoderma* sp.

Conc. (%)			0.5	1.0	1.5	2.0	2.5	3.0
Different nitrogen sources	Peptone	1	0.31 ± 0.04	2.21 ± 0.08	1.89 ± 0.07	1.52 ± 0.07	0.91 ± 0.06	0.53 ± 0.04
		2	0.32 ± 0.05	1.93 ± 0.07	1.62 ± 0.06	0.84 ± 0.06	0.63 ± 0.05	0.48 ± 0.04
		3	0.37 ± 0.03	1.94 ± 0.06	1.71 ± 0.07	0.91 ± 0.06	0.46 ± 0.05	0.39 ± 0.05
	Yeast extract	1	0.39 ± 0.04	2.40 ± 0.08	1.78 ± 0.07	0.92 ± 0.06	0.58 ± 0.06	0.43 ± 0.04
		2	0.31 ± 0.03	2.28 ± 0.07	1.87 ± 0.07	0.92 ± 0.05	0.62 ± 0.05	0.43 ± 0.03
		3	0.27 ± 0.04	1.99 ± 0.07	1.72 ± 0.07	1.41 ± 0.06	0.75 ± 0.05	0.55 ± 0.04
	Beef extract	1	0.41 ± 0.05	1.93 ± 0.07	1.69 ± 0.07	1.21 ± 0.06	0.93 ± 0.05	0.51 ± 0.04
		2	0.32 ± 0.05	1.79 ± 0.07	1.62 ± 0.06	0.93 ± 0.06	0.60 ± 0.05	0.42 ± 0.05
		3	0.22 ± 0.04	1.95 ± 0.05	1.71 ± 0.05	0.96 ± 0.04	0.61 ± 0.04	0.33 ± 0.03
	Ammonium nitrate	1	0.24 ± 0.04	1.73 ± 0.06	1.47 ± 0.06	0.89 ± 0.05	0.64 ± 0.04	0.30 ± 0.04
		2	0.19 ± 0.03	1.64 ± 0.06	1.23 ± 0.06	0.82 ± 0.05	0.67 ± 0.05	0.31 ± 0.04
		3	0.15 ± 0.03	1.69 ± 0.06	1.44 ± 0.06	0.88 ± 0.04	0.63 ± 0.04	0.28 ± 0.03
	Sodium nitrate	1	0.31 ± 0.03	1.76 ± 0.07	1.53 ± 0.06	0.99 ± 0.06	0.65 ± 0.04	0.41 ± 0.04
		2	0.22 ± 0.03	1.56 ± 0.05	1.44 ± 0.05	0.84 ± 0.04	0.67 ± 0.04	0.51 ± 0.03
		3	0.11 ± 0.03	1.74 ± 0.05	1.11 ± 0.05	0.68 ± 0.05	0.54 ± 0.04	0.31 ± 0.03

1-FPase, 2-CMCase & 3-β-glucosidase.

production, as was reported before, they were not an effective replacement for inorganic nitrogen sources because of their higher cost [32].

3.2.6. Effect of Municipal Solid Waste Residue in Enzyme Production. In the present investigation, municipal solid waste residue was used as a cheap and easily available carbon source for cellulase enzyme production. The results revealed that MSW residue (4.0%) was the best carbon substrate for exoglucanase (1.19 U/mL), endoglucanase (1.504 U/mL), and β-glucosidase (1.39 U/mL) by *A. niger* as shown in Figure 4, while in case of *Trichoderma* sp. 4.0% MSW residue was best for cellulase (exoglucanase (1.77 U/mL), endoglucanase (1.95 U/mL), and β-glucosidase (1.66 U/mL)) enzyme production (Figure 8). These results were confirmed by the results of [33]. This variation may be attributed to the chemical nature and nutrient availability of the used substrates.

4. Conclusions

In this investigation, the culturing of *A. niger* and *Trichoderma* sp. proved to be an excellent source for the enzymes production. In the present study, these cultures produced an amount of enzyme 40 to 60% higher than other fungi. Municipal solid waste in the form of cellulose which is the most abundant renewable biomass in the biosphere has been shown to be used in the production of valuable products by *A. niger* and *Trichoderma sp.* Municipal solid waste residue could provide an economical advantage as a solid substrate