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Fungi in the sewage-treatment Zeinein plant, Cairo, Egypt

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Abstract: Forty four species of yeasts and filamentous fungi were recovered from 60 wastewater samples collected monthly from 5 steps of treatments for one year (from April-2008 to March-2009). Regarding species richness *Aspergillus* and *Penicillium* revealed the broadest spectra of species. Sixteen species of *Aspergillus* and ten species of *Penicillium*. Four other genera were also represented by more than one species and these were: *Fusarium* (4 species), *Trichoderma* (3 species), *Mucor* and *Paecilomyces* (two species each). Nine genera were represented by one species and these were: *Acremonium, Blastomyces, Geotrichum, Humicola, Hypomyces, Rhizopus, Scopulariopsis, Syncephalastrum and Zygorhynchus. M. circinelloides, G. candidum A. flavus, A. niger* and *F. oxysporum* showed high frequency of occurrence. *A. fumigatus, A. ochraceus, A. oryzae, P. expansum, P. chrysogenum, T. harzianum* and *Z. moelleri* showed medium frequency of occurrence. Remaining species occurred in low or rare frequency. The highest species diversity (15 species) was recorded during November while the lowest (10 species) was recorded during the period July-September. Wastewater samples collected during February showed the highest abundance (24.0% of total count) whereas those collected during July yielded the lowest population (3.9% of total count). The greatest count (53 CFU/ml) was recorded in samples of the fourth step which were collected during February, whereas the poorest one (0.4 CFU/ml) was recorded in the samples collected from the fifth step during July. The highest numbers of genera (14) and species (41) were isolated from the second step, while the lowest number of genera (9) and species (28) were isolated from the fifth step proving that the wastewater treatment markedly reduced the number of inhabiting fungi and spectra of genera and species. The number of genera and species also fluctuated monthly within each step of wastewater treatment.

Key words: Fungi, sewage, wastewater, diversity, fluctuation.

Introduction

Fungi are widely distributed in nature and can occur as unicellular yeasts or filamentous, multicellular molds. They are universally present in all types of natural water bodies and form one of the most important components of any ecosystem as decomposers (El-Hissy *et al.* 1990). They are also common in sewage and polluted water (Becker and Shaw 1955). In addition, certain species of these fungi occur regularly in such habitats and apparently are able to multiply therein (Cooke 1954 a, b & c). Consequently, the ecology of these fungi has been extensively studied. Cooke (1963) has published a comprehensive laboratory manual for isolating and identifying fungi in wastewaters. In 1970, Cooke and Pipes isolated 20 species of fungi and yeasts from 18 activated sludge plants and the widest distribution in these samples belonged to *G. candidum*, *Trichosporon* spp and *Penicillium* spp. But the highest proportions of the total count observed belonged to *Acremonium* spp (38%), *Cladosporium cladosporioides* (22%) and *Penicillium* spp. (19%), while it was only 1% of the total colonies for yeasts. Seasonally, Pike and Curds (1971) observed that the smallest numbers and the fewest species of fungi were found in the winter and both increased to a peak in the autumn. Also, several investigators studied the fungal population inhabiting sewage and sludge (El-Dohlob and Batool 1981, Gray 1982, Niebla *et al.* 1982 and Passman 1983). Kacprzak *et al.* (2003) showed that yeasts, *Penicillium* and mucoraceous fungi occurred most commonly in the samples of wastewater collected from eight wastewater treatment plants (five of the biological type and three of constructed wetlands). Kacprzak *et al.* (2005) showed that, the recognition of fungal species inhabiting sewage sludge on different stages of wastewater treatment is insufficient.

The present investigation aimed to study the fluctuations of fungi inhabiting five steps in Zeinein plant for wastewater treatment, north Cairo, Egypt.

Materials and Methods

Collection of samples

The steps in Zenein plant from which samples were taken included: 1. raw sewage, 2. primary influent (after grease removal and before primary treatment), 3. primary effluent (after primary treatment), 4. secondary effluent (after secondary treatment), and 5. final effluent (after chlorination). The first two steps were the primary stage of treatment and the other three steps from the secondary (last) stage of treatment in the plant. Ten samples (200ml each) were collected from different places in the five steps using sterile screw-capped bottles opened under water surface, during the period from April 2008 to March 2009. Samples of each step were mixed and kept at 4ºC.

Isolation and identification of fungi

This was carried out using the dilution plate method (Johnson *et al.* 1959) and modified Waksman medium. One ml of mixed samples of each step (immediately after collection) was transferred aseptically into each of five sterile Petri plates using Menzies's dipper (Menzies 1957) which has been recommended by Watson (1960) and Moubasher (1993). Cultures were incubated at 28±2ºC for 7-15 days, during which developing fungi were examined, identified and counted, and the average number of colonies per one ml sewage was calculated. Isolated fungi were purified using single spore technique and identified according to Raper and Thom (1949), Rifai (1969), Ellis (1971), Booth (1971), Raper and Fennell (1965), O'Donnell (1979), Pitt (1979), Domsch *et al*. (1980), Moubasher (1993), Barnett and Hunter (1994) and Moustafa (2006).

Media used

Modified Waksman medium (where sucrose was substituted by glucose) was used as recommended by Ottova and Sladka (1966). It constitutes (g/L) glucose, 10.0; peptone, 5.0; beef extract, 5.0 and sodium chloride, 5.0 was used for isolation of fungi. A mixture of penicillin and streptomycin (0.1µg/ml) and rose bengal (70µg/ml) were used as bacteriostatic agents (Martin 1950 and Kacprzak *et al.* 2005). The following media were used for transferred inoculation and identification:

Potato-dextrose agar (PDA) (g/L): It consists of extract of 200 potato (scrubbed and diced); dextrose, 15 and agar, 20 (Booth 1971).

Czapek's agar (g/L): Sucrose, 30.0; sodium nitrate, 3.0; potassium dihydrogen phosphate, 1.0; potassium chloride, 0.5; magnesium sulphate, 0.5; ferrous sulphate, 0.01 and agar, 15.0 (Atlas 2005).

Malt extract agar (g/L): malt extract, 20.0 and agar, 20.0 (Raper and Fennell 1977).

Results and Discussion

Fungi recorded

Forty four species and two varieties belonging to fifteen genera in addition to some yeast isolates were recovered from 60 wastewater samples collected monthly for one year (5 samples /month) during the period from April 2008 to March 2009 (Table 1). Kacprzak *et al.* (2005) found that Waksman medium gave good accounts for the primary isolation of fungi from wastewater. El-Nagdy and Khallil (1991) identified 62 species and two varieties belonging to 20 genera of glucophilic fungi from 25 sewage samples. *Aspergillus* and *Penicillium* contributed the broadest spectra of species. Sixteen species of *Aspergillus* were identified. These species belong to seven groups as described by Raper and Fennell (1965) as follows: five species to *A. niger* group, three species to *A. versicolor* group, two species to each of *A. ochraceus*, *A. flavus*, *A. wentii* and *A. flavipes* groups and one species to *A. fumigatus* group. Eight species of *Penicillium* in addition to two varieties were also identified. Four genera were represented by more than one species as follows: *Fusarium* (4 species), *Trichoderma* (3 species) and both *Mucor* and *Paecilomyces* were represented by two species. The remaining nine genera were represented by one species, namely *Acremonium, Blastomyces, Geotrichum, Humicola, Hypomyces, Rhizopus, Scopulariopsis, Syncephalastrum and Zygorhynchus.* El-Nagdy and Khallil (1991) reported that *Aspergillus* (16 species + 2 varieties), *Penicillium* (11 species) and *Fusarium* (6 species) were the commonest glucophilic genera in 25 sewage samples. Sludge bulking may be caused by *Geotrichum* spp. which can regularly dominate the biota in a waste-water treatment plant (Hawkes 1963, Schofield 1971, Eikelboom 1975). This organism was isolated in bulking sludge by Pipes and Jones (1963) but probably has been mistakenly identified as *Sphaerotilus*. It appears to have a competitive advantage over the microbial population as a whole, when nitrogen and/or phosphorus are limiting factors (Jones 1965, Thanh and Simard 1973).

Results in Table (1) showed also that *M. circinelloides*, *G. candidum*, *A. flavus*, *A. niger* and *F. oxysporum* were isolated in high frequency of occurrence. Seven species were isolated in medium frequency of occurrence, these are *A. fumigatus*, *A. ochraceus*, *A. oryzae*, *P. chrysogenum*, *P. expansum*, *T. harzianum* and Z. *moelleri*. Ten species occurred in low frequency, namely *A. flavipes*, *A. japonicus*, *A. sulphureus*, *A. sydowi*, *A. we*ntii, *F. lateritium*, *Humicola fuscoatra*, *M. racemosus*, *P. rubrum* and *R. arrhizus*. The remaining fungal species occurred in rare frequency of occurrence.

Monthly fluctuation

The highest species diversity (15 species) was recorded during November 2008 while the lowest (10 species) was recorded during July, August and September 2008. The wastewater samples collected during February 2009 exhibited the highest abundance (24.0% of total count) whereas those collected during July yielded the lowest population (3.9% of total count). The richest count (53 CFU/ml) was recorded in samples of the fourth step during February, whereas the poorest (0.4 CFU/ml) was in the samples collected from the fifth step during July (Tables 2-7). The highest total monthly count (166.8 CFU/ml) of fungi was recorded during February 2009 whereas the lowest (27.2 CFU/ml) was observed in July 2008 as shown in Table (2). During these months the physicochemical characteristics of sewage were as follows: pH-values (7.4 and 7.3), biological oxygen demand (BOD: 152 and 175 mg/L) and chemical oxygen demand (COD: 237 and 335 mg/L), temperature (20.1 and 22.1°C), electrical

conductivity (857 and 999 µs/cm), dissolved oxygen (DO: 1.8 and 2.0 mg/L), total dissolved solids (TDS: 409 and 531 mg/L), total suspended solids (TSS: 189 and 429 mg/L), ammonia (8.1 and 23.3 mg/L), phosphate (3.7 and 6.4 mg/L), Fe^{+2} (4.5 and 21.3 mg/L) and Mn^{+2} (0.16 and 0.39 mg/L) respectively (Helal *et al.* unpublished data). Abdel-Hafez and El-Sharouny (1987) found that the highest counts of glucophilic fungi in soil receiving sewage were estimated in March (429 CFU/ml) and the lowest in June (7 CFU/ml).

Aspergillus was the most frequent genus emerging from all experimental steps constituting 50.1% of the total count of fungi. The richest month was February (113.8 CFU/ml) where a wide spectrum of the genus *Aspergillus* (8 species) was recorded. *A. flavus* and *A. niger* were the most prevalent species and were monitored in 5.2% and 5.0% of total count of fungi respectively. The monthly count of *A. flavus* and *A. niger* fluctuated between 0.6-12.2 CFU/ml and 0.6-9.6 CFU/ml, respectively. *A. flavus* appeared in all months of the year while *A. niger* appeared in 11 months (out of 12) and was missed during March. *A. fumigatus* appeared in eight months but was completely missed in October, November, February and March. Five species of *Aspergillus* appeared in rare frequency of occurrence during one or two months, namely *A. asperescens, A. ficuum, A. niveus, A. terricola* and *A. versicolor*. These fungi yielded 2.8%, 1.1%, 0.6%, 0.5% and 0.1% of the total count of fungi respectively.

Penicillium ranked second and was recorded in 68.3% of total samples matching 7.5 % of total fungi. The highest counts (12.4 CFU/ml) were recorded during June, while the lowest (0.6 CFU/ml) during January. The highest species diversity (5 species) was recorded during October. The highest count (4.0 CFU/ml) was estimated in the second step of treatment during October. *P. chrysogenum* was the only species regularly isolated during eight consecutive months while *P. expansum* was isolated from samples obtained during four months. Other *Penicillium* species appeared in one and two months only.

Fusarium occupied the third position according to the number of species (4) isolated. It was isolated from wastewater samples analyzed during nine months and was missed during May, October and March. The highest count (23.4 CFU/ml) was recorded during February and the lowest count (1.6 CFU/ml) during July. *F. oxysporum* was the only species of this genus which was isolated in high frequency of occurrence. The highest count (6.6 CFU/ml) was estimated during August and the lowest (0.4 CFU/ml) during September. *F. lateritium* was isolated in low frequency of occurrence with monthly counts fluctuating between 1.4 and 3.0 CFU/ml. *F. poae* and *F. solani* were isolated in rare frequency of occurrence. *Trichoderma* ranked fourth according to the number of species. It was represented by 3 species, namely *T. harzianum, T. koningii* and *T. viride*. It was recorded in 31.7% of the samples comprising 1.7% of the total fungi. The highest count (3.8 CFU/ml) was recorded during April and lowest (0.6 CFU/ml) during February and March. This genus was represented during eight months. *T. harzianum* appeared at medium frequency during 6 months contributing 1.4% of total fungi. *T. koningii* and *T. viride* appeared in rare frequency of occurrence during three and one month respectively. *Mucor* appeared in most cases of isolation during the twelve months. The highest total count (27.4 CFU/ml) was recorded during February and the lowest (4.6 CFU/ml) during June. It was represented by two species namely *M. circinelloides* and *M. racemosus*. *M. circinelloides* appeared in high frequency of occurrence during 10 months contributing 13.6% of the total count of fungi. The highest count of this species (5.8 CFU/ml) was recorded in the third step (Table 5) of treatment during November but the lowest count (0.2 CFU/ml) in the fourth and fifth steps (Tables 6 and 7) during June and August. *M. racemosus* appeared in low frequency contributing 6.9% of the total count of fungi. It appeared in three months out of 12. The highest count (8.4 CFU/ml) was recorded in the forth step (Table 6) of treatment during February and the lowest (0.4 CFU/ml) in the first step (Table 3) during December. *Paecilomyces* was isolated in rare frequency and was represented by two species, namely *P. fumosoroseus* and *P. variotii*.

G. candidum appeared in high occurrence during 12 months contributing 5.2% of the total count of fungi. The highest count of this species (2.8 CFU/ml) was recorded in the first step (Table 3) of treatment during August but the lowest count (0.2 CFU/ml) in the fifth step (Table 6) during May and December. *Zygorrhynchus moelleri* was isolated from the five steps of wastewater treatment during April, May, June, July, August and March with medium frequency representing 4.1% of the total count of fungi. The highest count (2.6 CFU/ml) was estimated in the second step during May.The other genera appeared during this study represented by one species each are *Humicola* (*H. fuscoatra*) was isolated in low frequency of occurrence. *Blastomyces* (*B. dermatitidis*), *Hypomyces* (*H. chrysospermus*), *Rhizopus* (*R. arrhizus*), *Scopulariopsis* (*S. brevicaulis*) and *Syncephalastrum* (*S. racemosum*) occurred in rare frequency. *B. dermatitidis* appeared in the fifth step during August with total count of 2.6 CFU/ml. *H. fuscoatra* appeared during April, May and March with highest count (0.6 CFU/ml) in the third step during May. *H. chrysospermus* was isolated only from the second step during April with total count (0.2 CFU/ml). *R. arrhizus* was isolated from the fifth step during September and from the fourth step during March. However, its highest total count (1.4 CFU/ml) was

recorded during the second step in July and the lowest (0.4 CFU/ml) during second and third steps in December. *S. racemosum* was isolated from first step during May (0.2 CFUs/ml) and from the fifth step (0.4 CFUs/ml) during October.

Fluctuation of fungi during treatment steps

The results in Tables (3-7) indicate that the highest numbers of genera (14) and species (41) were isolated from the second step while the lowest (9 genera and 28 species) were recovered from the fifth step. The highest total count of fungi was recorded in the third step (175.8 CFUs/ml) whereas the lowest (59.0 CFUs/ml) was recorded in the fifth (last) step of wastewater treatment. In the first step (Table 3) 37 species belonging to 11 genera were isolated during the year of study. *G. candidum, A. flavus, A. niger* and *M. circinelloides* were of high frequency of occurrence respectively. *G. candidum* appeared in all months, *M. circinelloides* regularly appeared in 10 months and was missed during the last two months. *A. niger* and *A. flavus* appeared in relatively low counts during 9 and 7 months, respectively. *A. ochraceus, A. oryzae*, *F. oxysporum, P. chrysogenum, P. expansum, T. harzianum and Z. moelleri* were present in medium frequency of occurrence.

In the second step of wastewater treatment (Table 4), the richest month in fungi was June (8 genera and 13 species) and the poorest months were October (4 genera) and November (6 species). *G. candidum, A. fumigatus, A. niger* and *M. circinelloides* dominated in high frequency of occurrence. *G. candidum* appeared in all months and *M. circinelloides* disappeared only during February and March. *A. flavus, A. ochraceus, A. oryzae, F. oxysporum* and *Z. moelleri* were present in medium frequency of occurrence.

In the third step, thirty eight species belonging to 13 genera were present (Table 5). The highest number of genera (8) and species (11) were recorded during May and the lowest during September (4 genera and 4 species). *A. flavus* and *M. circinelloides* appeared in high frequency of occurrence. *M. circinelloides* disappeared during February and March, while *A. flavus* disappeared from November to March. *A. fumigatus, A. niger, A. ochraceus, A. oryzae, F. oxysporum, G. candidum, P. chrysogenum, P. expansum, T. harzianum* and *Z. moelleri* were present in medium frequency of occurrence.

Eleven genera comprising 39 species are recorded in the forth step of wastewater treatment during 12 months (Table 6). The highest number of genera (7) and species (13) are recorded during June and the lowest 3 genera and 6 species during October. *A. flavus, A. fumigatus, F. oxysporum, M. circinelloides* and *P. chrysogenum* were present in high frequency of occurrence. *M. circinelloides* disappeared during February and March. *A. niger, A. ochraceus, A. oryzae, G. candidum and Z. moelleri* were present in medium frequency of occurrence appearing during 4-6 months.

In the fifth (last) step of wastewater treatment the number of genera and species decreased to 9 genera and 28 species (Table 7). The highest number of genera (6) and species (9) was recorded during June and the lowest (2 genera and 2 species) during July. *F. oxysporum* and *M. circinelloides* were present in high frequency of occurrence (NCI 7/12). *A. flavus, A. fumigatus, A. niger, A. oryzae* and *Z. moelleri* were isolated in medium frequency of occurrence (NCI 4-6/12). The remaining species were isolated in low and rare frequency as shown in tables (3-7).

According to the report of Kacprazak *et al.* (2005), the quantitative analysis of microscopic fungi samples obtained from five wastewater treatment plants in Poland showed that quantity of fungi was very different and the number of CFU oscillated in untreated wastewater (31×10^3-167×10^3/cm^3) was significantly higher as compared to treated wastewater (220- 750CFU/cm^3) and finally in sewage sludge (43×10^3/g to 182×10^3/g of dry solids). They added that the most frequently occurred fungi belonged to genus *Penicillium* (*P. commune, P. lividum, P. vulpinum, P. janczewskii, P. spinulosum* and *P. granulatum*), next yeast and yeast-like fungi which were represented by *Candida* (*C. albicans, C. krusei*), and *Geotrichum* (*G. candidum*) and finally representatives of family *Mucoraceae*: *Mucor* (*M. racemosus, M. hiemalis*), *Absidia* (*A. glauca*), *Mortierella* (*M. alpina, M. exigua*) and *Zygorrhynchus* (*Z. moelleri*).

The frequency of occurrence of the 46 species isolated monthly during one year of study from the five steps of wastewater treatment in Zeinein plant can be grouped into: (i) high; *M. circinelloides*, (ii) medium; *A. oryzae* and *Z. moelleri*, (iii) high or medium; *A. flavus, A. niger* and *F. oxysporum*, (iv) low; *A. flavipes, A. japonicus, A. sydowi, A. terricola, F. lateritium* and *M. racemosus*, (v) high, medium or low; *A. fumigatus, G. candidum*, and *P. chrysogenum*, (vi) medium or low; *A. ochraceus, P. expansum* and *T. harzianum*, (vii) rare only; *A. strictum, A. ficuum, A. niveus, A. versicolor, B. dermatitidis, F. solani, H. chrysospermus, P. fumosoroseus, P. variotii, P. camemberti, P. griseofulvum, P. velutinum, P. verrucosum, S. racemosum* and *T. viride* and (viii) low or rare; *A. asperescens, A. phoenicis, A. sulphureus, A. wentii, F. poae, H. fuscoatra, P. claviforme, P. commune, P. rubrum, P. steckii, R. arrhizus, S. brevicaulis* and *T. koningii*.

In conclusion, the total fungal counts in wastewater markedly declined to about one-third (from 159.4 to 59.0 CFU/ml) during the consecutive steps of treatments till the fifth step. The numbers of genera and species also decreased.

Table (1): Frequency of occurrence of fungi isolated from sewage treatment plant during April 2008-March 2009.

Number of cases of isolation during each month														
Species \ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	NCI	OR
Acremonium strictum W. Gams	-	2	-	-	-	-	-	-	-	-	-	-	2	R
Aspergillus asperescens Stolk	-	-	-	-	-	-	-	-	-	-	5		5	R
A. flavipes (Baini. & Sar.) Thom and Church	4		-	-	-	-	-	-	-	-	4	5	13	L
A. flavus link	5	5	3	4	5	4	4	1	-	-	-	-	31	H
A. ficuum (Reich.) Hennings	-	-	-	-	-	-	-	-	-	4	-	-	4	R
A. fumigatus Fresenius	5	4	4	3	3	3	-	-	2	4	-	-	28	M
A. japonicus Saito	-	-	4	5	-	-	-	-	-	-	-	-	9	L
A. niger van Tieghem	2	5	5	3	5	2	4	1	1	5	-	-	33	H
A. niveus Blochwitz	-	-	-	-	-	-	-	1	-	1	-	-	2	R
A. ochraceus Wilhelm	-	-	-	-	-	-	-	5	-	5	4	5	19	M
A. oryzae (Ahlburg) Chon	4	-	-	-	-	-	5		5	3	3	5	25	M
A. phoenicis (Cda.) Thom	-	-	-	-	-	-	-	3	2	-	5	-	10	L
A. sulphureus (Fresenius) Thom and Church	-	-	-	-	-	-	-	-	-	-	5	4	9	L
A. sydowii (Bain. and Sart.)Thom and Church	-	-	-	-	-	-	-		4	4	3	-	11	L
A. terricola Marchal	-	-	-	-	-	-	-	4	-	-	-	-	4	R
A. versicolor (Vuill) Tiraboschi	-	-	-	-	-	-	3	-	-	-	-	-	3	R
A. wentii Wehmer	-	-	-	-	-	-	-	-	-	-	5	3	8	L
Blastomyces dermatitidis Gilchrist and Stokes	-	-	-	-	4	-	-	-	-	-	-	-	4	R
Fusarium lateritium Nees	-	-	-	-		-	-	3	3		5	-	11	L
F. oxysporum Schlecht	4	-	5	4	5	2	-	3	3	5	-	-	31	H
F. poae (Peck) Wollenw	-	-	2	-	-	-	-	-	-	1	-	-	3	R
F. solani (Mart.) Sacc.	-	-	-	-	-	3	-	-	-	-	-	-	3	R
Geotrichum candidum Link	3	3	3	3	4	2	4	3	4	2	2	3	36	H

Table (1): Continued

Species \ Month	Number of cases of isolation during each month													
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	NCI	OR
Humicola fuscoatra Traaen	2	2	-	-	-	-	-	-	-	-	-	4	8	L
Hypomyces chrysospermus Tul.	1	-	-	-	-	-	-	-	-	-	-	-	1	R
Mucor circinelloides van Tieghem	5	5	5	4	4	5	5	5	5	4	-	-	47	H
M. racemosus Fresenius	-	-	-	-	-	-	-	-	4	-	5	5	14	L
Paecilomyces fumosoroseus (Wize) Brown & Sm.	-	1	-	-	-	-	-	-	-	-	-	-	1	R
P. variotii Bainier	3	-	-	-	-	-	-	-	-	-	-	-	3	R
Penicillium camemberti Thom	-	-	-	-	-	-	-	-	-	-	-	2	2	R
P. chrysogenum Thom	3	2	5	3	1	2	3	4	-	-	-	-	23	M
P. claviforme Bainier	-	-	-	-	-	-	2	3	-	-	-	-	5	R
P. commune Thom	-	-	-	-	-	-	-	-	5	2	-	-	7	R
P. expansum Link	-	5	5	-	-	-	3	2	-	-	-	-	15	M
P. griseofulvum Dierckx	-	-	-	-	-	-	-	1	-	-	-	-	1	R
P. rubrum Stoll	-	3	5	-	-	-	1	-	-	-	-	-	9	L
P. steckii Zaleski	-	-	-	-	2	4	-	-	-	-	-	-	6	R
P. velutinum van Beyma	-	-	-	-	-	-	4	-	-	-	-	-	4	R
P. verrucosum Dierckx	-	-	-	-	-	-	-	-	-	-	-	4	4	R
Rhizopus arrhizus Fisher	-	-	5	-	-	5	-	-	-	-	-	1	11	L
Scopulariopsis brevicaulis (Saccardo) Bainier	-	-	-	1	-	-	-	-	2	-	-	-	3	R
Syncephalastrum racemosum Cohn ex Schroter		1	-	-	-	-	1	-	-	-	-	-	2	R
Trichoderma harzianum Rifai	2	3	4	-	-	-	-	4	2	2	-	-	17	M
T. Koningii (Oudemans) Duche &Heim	-	-	-	-	-	-	-	-	1	1	2	-	4	R
T. viride Persoon ex Gray	-	-	-	-	-	-	-	-	-	-	-	3	3	R
Zygorrhynchus moelleri Vuill	4	5	5	3	5	-	-	-	-	-	-	5	27	M

NCI: number of cases of isolation

OR: occurrence remark: H= high occurrence isolated more than 30 cases out of 60; M= moderate occurrence 15 to 30 cases; L= low occurrence 8 to 14 cases; R= rare occurrence less than 8 cases.

Table (2): Monthly average total counts of fungi (CFU/ml) isolated from the five steps of wastewater treatment plant during (April 2008 - march 2009) on modified Waksman medium incubated at 28ºC for 15 days

Species \ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	T.C
Acremonium strictum	-	0.4	-	-	-	-	-	-	-	-	-	-	0.4
Aspergillus asperescens	-	-	-	-	-	-	-	-	-	-	19.8	-	19.8
A. flavipes	1.8	-	-	-	-	-	-	-	-	-	3.4	5.2	10.4
A. flavus	12.2	4.8	1.0	1.8	4.2	3.6	8.0	0.6	-	-	-	-	36.2
A. ficuum	-	-	-	-	-	-	-	-	-	7.8	-	-	7.8
A. fumigatus	11.8	4.4	2.8	1.6	4.2	1.6	-	-	1.2	5.2	-	-	32.8
A. japonicus	-	-	1.0	4.0	-	-	-	-	-	-	-	-	5.0
A. niger	0.8	3.8	9.6	5.8	5.0	0.6	2.6	0.2	0.8	5.6	-	-	34.8
A. niveus	-	-	-	-	-	-	-	3.2	-	0.8	-	-	4.0
A. ochraceus	-	-	-	-	-	-	-	22.0	-	14.6	14.2	16.4	67.2
A. oryzae	6.2	-	-	-	-	-	5.2	-	10.0	6.6	3.2	3.4	34.6
A. phoenicis	-	-	-	-	-	-	-	1.2	0.6	-	26.0	-	27.8
A. sulphureus	-	-	-	-	-	-	-	-	-	-	7.2	3.0	10.2
A. sydowii	-	-	-	-	-	-	-	-	5.4	4.6	1.4	-	11.4
A. terricola	-	-	-	-	-	-	-	3.2	-	-	-	-	3.2
A. versicolor	-	-	-	-	-	-	0.8	-	-	-	-	-	0.8
A. wentii	-	-	-	-	-	-	-	-	-	-	38.6	3.8	42.4
Blastomyces dermatitidis	-	-	-	-	2.6	-	-	-	-	-	-	-	2.6
Fusarium lateritium	-	-	-	-	-	-	-	3.0	1.4	-	23.4	-	27.8
F. oxysporum	2.8	-	5.4	1.6	6.6	0.4	-	3.6	1.0	6.4	-	-	27.8
F. poae	-	-	0.6	-	-	-	-	-	-	0.2	-	-	0.8
F. solani	-	-	-	-	-	2.0	-	-	-	-	-	-	2.0
Geotrichum candidum	2.4	2.4	2.2	4.8	6.2	4.2	5.0	2.6	2.0	1.0	1.6	1.6	36.0

Table (2): continued

Month / Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	T.C
Humicola fuscoatra	0.4	1.0	-	-	-	-	-	-	-	-	-	1.2	2.6
Hypomyces chrysospermus	0.2	-	-	-	-	-	-	-	-	-	-	-	0.2
Mucor circinelloides	12.2	6.0	4.6	4.8	6.8	12.4	8.8	19.8	10.2	9.2	-	-	94.8
M. racemosus	-	-	-	-	-	-	-	-	4.4	-	27.4	16.4	48.2
Paecilomyces fumosoroseus	-	0.2	-	-	-	-	-	-	-	-	-	-	0.2
P. variotii	0.8	-	-	-	-	-	-	-	-	-	-	-	0.8
Penicillium camemberti	-	-	-	-	-	-	-	-	-	-	-	1.2	1.2
P. chrysogenum	4.8	1.0	4.6	0.8	0.2	0.4	1.0	2.0	-	-	-	-	14.8
P. claviforme	-	-	-	-	-	-	0.4	2.8	-	-	-	-	3.2
P. commune	-	-	-	-	-	-	-	-	2.2	0.6	-	-	2.8
P. expansum	-	3.8	3.8	-	-	-	5.2	1.0	-	-	-	-	13.8
P. griseofulvum	-	-	-	-	-	-	-	0.2	-	-	-	-	0.2
P. rubrum	-	0.8	4.0	-	-	-	0.6	-	-	-	-	-	5.4
P. steckii	-	-	-	-	0.6	2.2	-	-	-	-	-	-	2.8
P. velutinum	-	-	-	-	-	-	4.6	-	-	-	-	-	4.6
P. verrucosum	-	-	-	-	-	-	-	-	-	-	-	3.0	3.0
Rhizopus arrhizus	-	-	4.2	-	-	4.2	-	-	-	-	-	0.6	9.0
Scopulariopsis brevicaulis	-	-	-	0.2	-	-	-	-	0.6	-	-	-	0.8
Syncephalastrum racemosum	-	0.2	-	-	-	-	0.4	-	-	-	-	-	0.6
Trichoderma harzianum	3.8	0.8	1.2	-	-	-	-	2.6	0.6	1.0	-	-	10.0
T. koningii	-	-	-	-	-	-	-	-	0.4	0.2	0.6	-	1.2
T. viride	-	-	-	-	-	-	-	-	-	-	-	0.6	0.6
Zygorrhynchus moelleri	2.4	8.2	3.2	1.8	7.6	-	-	-	-	-	-	5.4	28.6
Total CFUs	62.6	37.8	48.2	27.2	44.0	31.6	42.6	68.0	40.8	63.8	166.8	61.8	695.2
Number of genera	10	10	8	7	7	6	5	6	7	6	5	8	-
Number of species	14	14	14	10	10	10	12	15	14	14	12	13	-

Table (3): Monthly average total counts (CFU/ml) of fungi in the first step* of wastewater treatment during the study period

Species \ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	T.C	NCI	OR
Aspergillus asperescens	-	-	-	-	-	-	-	-	-	-	0.4	-	0.4	1	R
A. flavipes	0.2	-	-	-	-	-	-	-	-	-	0.8	1.0	2.0	3	L
A. flavus	0.4	2.4	0.2	0.8	1.8	-	2.0	0.6	-	-	-	-	8.2	7	H
A. ficuum	-	-	-	-	-	-	-	-	-	3.0	-	-	3.0	1	R
A. fumigatus	0.4	0.4	-	1.0	-	-	-	-	-	1.8	-	-	3.6	4	L
A. japonicus	-	-	0.2	0.4	-	-	-	-	-	-	-	-	0.6	2	L
A. niger	0.2	0.8	2.8	3.4	0.8	0.4	0.6	0.2	-	2.4	-	-	11.6	9	H
A. ochraceus	-	-	-	-	-	-	-	4.6	-	4.4	3.6	6.4	19.0	4	M
A. oryzae	1.6	-	-	-	-	-	0.4	-	2.2	2.2	0.4	0.4	7.2	6	M
A. phoenicis	-	-	-	-	-	-	-	0.4	-	-	4.2	-	4.6	2	L
A. sulphureus	-	-	-	-	-	-	-	-	-	-	0.4	0.2	0.6	2	L
A. sydowii	-	-	-	-	-	-	-	-	0.8	0.2	0.4	-	1.4	3	L
A. terricola	-	-	-	-	-	-	-	0.2	-	-	-	-	0.2	1	R
A. versicolor	-	-	-	-	-	-	0.2	-	-	-	-	-	0.2	1	R
A. wentii	-	-	-	-	-	-	-	-	-	-	10.2	-	10.2	1	R
Blastomyces dermatitidis	-	-	-	-	1.4	-	-	-	-	-	-	-	1.4	1	R
Fusarium lateritium	-	-	-	-	-	-	-	-	0.4	-	2.4	-	2.8	2	L
F. oxysporum	1.4	-	1.4	-	1.0	-	-	0.8	-	0.6	-	-	5.2	5	M
F. solani	-	-	-	-	-	0.6	-	-	-	-	-	-	0.6	1	R
Geotrichum candidum	1.2	1.0	1.0	2.0	2.8	2.0	1.8	1.2	0.8	0.8	1.0	0.8	16.4	12	H
Humicola fuscoatra	0.2	-	-	-	-	-	-	-	-	-	-	0.2	0.4	2	L
Mucor circinelloides	4.0	1.0	1.4	3.0	1.8	2.4	2.6	4.0	2.4	3.2	-	-	25.8	10	H
M. racemosus	-	-	-	-	-	-	-	-	0.4	-	5.2	4.0	9.6	3	L
Penicillium camemberti	-	-	-	-	-	-	-	-	-	-	-	0.4	0.4	1	R
P. chrysogenum	2.2	-	1.4	0.4	-	0.2	0.6	0.8	-	-	-	-	5.6	6	M
P. claviforme	-	-	-	-	-	-	-	0.4	-	-	-	-	0.4	1	R
P. commune	-	-	-	-	-	-	-	-	0.4	-	-	-	0.4	1	R
P. expansum	-	0.2	0.4	-	-	-	1.8	0.4	-	-	-	-	2.8	4	M
P. rubrum	-	0.2	1.0	-	-	-	-	-	-	-	-	-	1.2	1	R
P. steckii	-	-	-	-	-	0.4	-	-	-	-	-	-	0.4	2	L
P. velutinum	-	-	-	-	-	-	1.0	-	-	-	-	-	1.0	1	R
P. verrucosum	-	-	-	-	-	-	-	-	-	-	-	0.8	0.8	1	R
Rhizopus arrhizus	-	-	0.4	-	-	0.4	-	-	-	-	-	-	0.8	2	L
Syncephalastrum racemosum	-	0.2	-	-	-	-	-	-	-	-	-	-	0.2	1	R
Trichoderma harzianum	-	0.2	0.2	-	-	-	-	1.6	0.2	0.6	-	-	2.8	5	M
T. Koningii	-	-	-	-	-	-	-	-	0.4	-	-	-	0.4	1	R
Zygorrhynchus moelleri	-	2.2	0.2	0.6	0.8	-	-	-	-	-	-	0.4	4.2	5	M
Total CFUs	11.8	8.6	10.6	11.6	10.4	6.4	11.0	15.2	8.0	19.2	29.0	14.6	156.4	12	H
Number of genera (11)	6	7	8	5	6	6	4	6	6	5	4	6	-	-	-
Number of species (37)	10	10	12	8	7	7	9	12	9	10	11	10	-	-	-

* Raw sewage

OR: occurrence remark: H= high occurrence isolated more than 6 cases out of 12; M= moderate occurrence 4 to 6 cases; L= low occurrence 2 to 3 cases; R= rare occurrence less than 2 cases.

Table (4): Monthly average total counts (CFU/ml) of fungi in the second step* of wastewater treatment during the study period

Species \ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	T.C	NCI	OR
Acremonium strictum	-	0.2	-	-	-	-	-	-	-	-	-	-	0.2	1	R
Aspergillus asperescens	-	-	-	-	-	-	-	-	-	-	2.0	-	2.0	1	R
A. flavipes	0.4	-	-	-	-	-	-	-	-	-	0.6	1.0	2.0	3	L
A. flavus	4.4	0.6	-	0.2	0.8	0.4	3.0	-	-	-	-	-	9.4	6	M
A. ficuum	-	-	-	-	-	-	-	-	-	3.8	-	-	3.8	1	R
A. fumigatus	1.8	2.2	0.8	0.4	2.8	0.4	-	-	0.4	1.4	-	-	10.2	8	H
A. japonicus	-	-	0.2	0.8	-	-	-	-	-	-	-	-	1.0	2	L
A. niger	0.6	1.2	3.6	1.6	0.2	0.2	0.4	-	-	1.0	-	-	8.8	8	H
A. ochraceus	-	-	-	-	-	-	-	5.2	-	4.8	2.4	4.4	16.8	4	M
A. oryzae	1.8	-	-	-	-	-	1.0	-	3.4	2,6	-	0.2	9.0	5	M
A. phoenicis	-	-	-	-	-	-	-	-	0.2	-	4.0	-	4.2	2	L
A. sulphureus	-	-	-	-	-	-	-	-	-	-	0.8	0.2	1.0	2	L
A. sydowi	-	-	-	-	-	-	-	-	1.0	0.8	0.2	-	2.0	3	L
A. terricola	-	-	-	-	-	-	-	1.4	-	-	-	-	1.4	1	R
A. versicolor	-	-	-	-	-	-	0.2	-	-	-	-	-	0.2	1	R
A. wentii	-	-	-	-	-	-	-	-	-	-	8.4	-	8.4	1	R
Blastomyces dermatitidis	-	-	-	-	0.4	-	-	-	-	-	-	-	0.4	1	R
Fusarium lateritium	-	-	-	-	-	-	-	-	0.4	-	3.6	-	4.0	2	L
F. oxysporum	-	-	1.6	0.2	2.0	0.2	-	-	0.4	2.6	-	-	7.0	6	M
F. poae	-	-	0.2	-	-	-	-	-	-	-	-	-	0.2	1	R
F. solani	-	-	-	-	-	0.6	-	-	-	-	-	-	0.6	1	R
Geotrichum candidum	1.0	1.2	1.0	1.6	2.4	2.2	1.8	1.0	0.8	0.2	0.6	0.6	14.4	12	H
Humicola fuscoatra	0.2	0.4	-	-	-	-	-	-	-	-	-	0.4	1.0	3	L
Hypomyces chrysospermus	0.2	-	-	-	-	-	-	-	-	-	-	-	0.2	1	R
Mucor circinelloides	3.4	1.6	1.8	1.2	1.4	4.0	2.2	5.6	4.0	2.0	-	-	27.2	10	H
M. racemosus	-	-	-	-	-	-	-	-	0.6	-	6.2	4.8	11.6	3	L
Paecilomyces fumosoroseus	-	0.2	-	-	-	-	-	-	-	-	-	-	0.2	1	R
P. variotii	0.2	-	-	-	-	-	-	-	-	-	-	-	0.2	1	R
Penicillium chrysogenum	-	-	1.2	-	-	-	0.2	-	-	-	-	-	1.4	2	L
P. claviforme	-	-	-	-	-	-	0.2	0.4	-	-	-	-	0.6	2	L
P. commune	-	-	-	-	-	-	-	-	0.6	0.2	-	-	0.8	2	L
P. expansum	-	0.2	0,4	-	-	-	1.4	-	-	-	-	-	2.0	3	L
P. rubrum	-	0.4	-	-	-	-	0.6	-	-	-	-	-	1.0	2	L
P. steckii	-	-	0.6	-	0.2	0.2	-	-	-	-	-	-	1.0	3	L
P. velutinum	-	-	-	-	-	-	1.6	-	-	-	-	-	1.6	1	R
P. verrucosum	-	-	-	-	-	-	-	-	-	-	-	1.2	1.2	1	R
Rhizopus arrhizus	-	-	1.0	-	-	1.4	-	-	-	-	-	-	2.4	2	L
Scopulariopsis brevicaulis	-	-	-	0.2	-	-	-	-	0.2	-	-	-	0.4	2	L
Trichoderma harzianum	1.2	-	0.4	-	-	-	-	0.4	-	-	-	-	2.0	3	L
T. Koningii	-	-	-	-	-	-	-	-	-	0.2	0.2	-	0.4	2	L
Zygorrhynchus moelleri	0.4	2.6	1.8	0.6	1.2	-	-	-	-	-	-	1.0	7.6	6	M
Total CFUs	15.6	10.8	14.6	6.8	11.4	9.6	12.6	14.0	12.0	19.6	29.0	13.8	169.4	12	H
No. of genera (14)	8	8	8	6	7	6	4	5	6	6	5	6	-	-	-
No. of species (41)	12	11	13	9	9	9	11	6	11	11	11	9	-	-	-

* Primary influent (after grease removal and before primary treatment)

Table (5): Monthly average total counts (CFU/ml) of fungi in the third step* of wastewater treatment during the study period

Species \ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	T.C	NCI	OR
A. strictum	-	0.2	-	-	-	-	-	-	-	-	-	-	0.2	1	R
A. asperescens	-	-	-	-	-	-	-	-	-	-	3.2	-	3.2	2	L
A. flavipes	1.0	-	-	-	-	-	-	-	-	-	1.4	1.8	4.2	3	L
A. flavus	3.6	1.0	0.2	0.4	0.4	1.2	2.2	-	-	-	-	-	9.0	7	H
A. ficuum	-	-	-	-	-	-	-	-	-	0.6	-	-	0.6	1	R
A. fumigatus	7.4	0.8	0.4	-	0.8	-	-	-	0.8	1.6	-	-	11.8	6	M
A. japonicus	-	-	0.4	1.6	-	-	-	-	-	-	-	-	2.0	2	L
A. niger	-	1.0	2.0	0.8	1.2	-	1.2	-	-	1.4	-	-	7.6	6	M
A. ochraceus	-	-	-	-	-	-	-	5.6	-	5.0	3.4	1.8	15.8	4	M
A. oryzae	2.6	-	-	-	-	-	2.2	-	2.4	1.8	0.6	0.6	10.2	6	M
A. phoenicis	-	-	-	-	-	-	-	-	-	-	6.0	-	6.0	1	R
A. sulphureus	-	-	-	-	-	-	-	-	-	-	2.0	1.6	3.6	2	L
A. sydowii	-	-	-	-	-	-	-	-	2.2	2.4	0.8	-	5.4	3	L
A. wentii	-	-	-	-	-	-	-	-	-	-	10.8	0.6	11.4	2	L
B. dermatitidis	-	-	-	-	0.2	-	-	-	-	-	-	-	0.2	1	R
F. lateritium	-	-	-	-	-	-	-	2.0	-	-	6.0	-	8.0	2	L
F. oxysporum	1.0	-	0.8	0.8	3.0	-	-	-	0.2	0.8	-	-	6.6	6	M
G. candidum	-	-	0.2	1.2	0.6	-	1.0	0.4	0.2	-	-	-	3.6	6	M
H. fuscoatra	-	0.6	-	-	-	-	-	-	-	-	-	0.4	1.0	2	L
M. circinelloides	1.6	1.4	0.4	0.4	1.6	3.2	1.8	5.8	2.2	2.2	-	-	20.6	10	H
M. racemosus	-	-	-	-	-	-	-	-	1.8	-	6.4	2.4	10.6	3	L
P. fumosoroseus	-	0.2	-	-	-	-	-	-	-	-	-	-	0.2	1	R
P. variotii	0.4	-	-	-	-	-	-	-	-	-	-	-	0.4	1	R
P. camemberti	-	-	-	-	-	-	-	-	-	-	-	0.8	0.8	1	R
P. chrysogenum	1.4	-	1.2	-	-	-	0.2	0.8	-	-	-	-	3.6	4	M
P. claviforme	-	-	-	-	-	-	0.2	1.2	-	-	-	-	1.4	2	L
P. commune	-	-	-	-	-	-	-	-	0.2	0.4	-	-	0.6	2	L
P. expansum	-	1.4	0.8	-	-	-	2.0	0.6	-	-	-	-	4.8	4	M
P. velutinum	-	-	-	-	-	-	1.4	-	-	-	-	-	1.4	1	R
P. verrucosum	-	-	-	-	-	-	-	-	-	-	-	0.8	0.8	1	R
P. rubrum	-	0.2	0.8	-	-	-	-	-	-	-	-	-	1.0	2	L
P. steckii	-	-	-	-	0.4	1.2	-	-	-	-	-	-	1.6	2	L
R. arrhizus	-	-	1.6	-	-	1.0	-	-	-	-	-	-	2.6	2	L
S. brevicaulis	-	-	-	-	-	-	-	-	0.4	-	-	-	0.4	1	R
T. harzianum	2.6	0.4	-	-	-	-	-	0.4	0.4	-	-	-	3.8	4	M
T. Koningii	-	-	-	-	-	-	-	-	-	-	0.4	-	0.4	1	R
T. viride	-	-	-	-	-	-	-	-	-	-	-	0.2	0.2	1	R
Z. moelleri	1.2	2.4	0.8	0.4	3.2	-	-	-	-	-	-	2.2	10.2	6	M
Total CFUs	22.8	9.6	9.6	5.6	11.4	6.6	12.2	15.0	10.8	16.8	41.0	13.2	175.8	12	H
No. of genera (13)	7	8	7	5	7	4	4	6	7	4	4	6	-	-	-
No. of species (38)	10	11	12	7	9	4	9	8	10	9	11	11	-	-	-

* Primary effluent (after primary treatment)

Table (6): Monthly average total counts (CFU/ml) of fungi in the forth step* of wastewater treatment during the study period

Species \ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	T.C	NCI	OR
Aspergillus asperescens	-	-	-	-	-	-	-	-	-	-	11.4	-	11.4	1	R
A. flavipes	-	-	-	-	-	-	-	-	-	-	0.6	1.2	1.8	2	L
A. flavus	3.0	0.4	0.6	0.4	0.6	1.0	0.8	-	-	-	-	-	6.8	7	H
A. ficuum	-	-	-	-	-	-	-	-	-	0.4	-	-	0.4	1	R
A. fumigatus	1.8	1.0	1.4	0.2	0.6	0.6	-	-	-	0.4	-	-	6.0	7	H
A. japonicus	-	-	0.2	1.0	-	-	-	-	-	-	-	-	1.2	2	L
A. niger	-	0.4	0.8	-	2.0	-	0.4	-	0.8	0.4	-	-	4.8	6	M
A. niveus	-	-	-	-	-	-	-	-	-	0.8	-	-	0.8	1	R
A. ochraceus	-	-	-	-	-	-	-	5.0	-	0.2	4.8	1.8	11.8	4	M
A. oryzae	-	-	-	-	-	-	0.2	-	1.4	-	2.2	1.0	4.8	4	M
A. phoenicis	-	-	-	-	-	-	-	0.2	-	-	7.6	-	7.8	2	L
A. sulphureus	-	-	-	-	-	-	-	-	-	-	2.4	1.0	3.4	2	L
A. sydowii	-	-	-	-	-	-	-	-	1.4	1.2	-	-	2.6	2	L
A. terricola	-	-	-	-	-	-	-	0.6	-	-	-	-	0.6	1	R
A. versicolor	-	-	-	-	-	-	0.4	-	-	-	-	-	0.4	1	R
A. wentii	-	-	-	-	-	-	-	-	-	-	8.4	1.8	10.2	2	L
Blastomyces dermatitidis	-	-	-	-	0.6	-	-	-	-	-	-	-	0.6	1	R
Fusarium lateritium	-	-	-	-	-	-	-	0.2	0.6	-	7.2	-	8.0	3	L
F. oxysporum	0.2	-	1.0	0.4	0.2	0.2	-	0.6	-	1.0	-	-	3.6	7	H
F. poae	-	-	0.4	-	-	-	-	-	-	0.2	-	-	0.6	2	L
F. solani	-	-	-	-	-	0.8	-	-	-	-	-	-	0.8	1	R
Geotrichum candidum	0.2	-	-	-	0.4	-	0.4	-	-	-	-	0.2	1.2	4	M
Humicola fuscoatra	-	-	-	-	-	-	-	-	-	-	-	0.2	0.2	1	R
Mucor circinelloides	2.0	1.0	0.8	0.2	2.0	2.0	1.0	2.0	1.0	1.8	-	-	10.0	10	H
M. racemosus	-	-	-	-	-	-	-	-	1.6	-	8.4	2.2	12.2	3	L
Paecilomyces variotii	0.2	-	-	-	-	-	-	-	-	-	-	-	0.2	1	R
Penicillium chrysogenum	1.2	0.4	0.6	0.2	0.2	0.2	-	0.2	-	-	-	-	3.0	7	H
P. claviforme	-	-	-	-	-	-	-	0.8	-	-	-	-	0.8	1	R
P. commune	-	-	-	-	-	-	-	-	0.8	-	-	-	0.8	1	R
P. expansum	-	1.2	1.6	-	-	-	-	-	-	-	-	-	2.8	2	L
P. griseofulvum	-	-	-	-	-	-	-	0.2	-	-	-	-	0.2	1	R
P. rubrum	-	-	1.2	-	-	-	-	-	-	-	-	-	1.2	1	R
P. steckii	-	-	-	-	-	0.4	-	-	-	-	-	-	0.4	1	R
P. velutinum	-	-	-	-	-	-	0.4	-	-	-	-	-	0.4	1	R
P. verrucosum	-	-	-	-	-	-	-	-	-	-	-	0.2	0.2	1	R
Rhizopus arrhizus	-	-	1.0	-	-	0.4	-	-	-	-	-	0.6	2.0	3	L
Trichoderma harzianum	-	0.2	0.6	-	-	-	-	-	-	-	-	-	0.8	2	L
T. viride	-	-	-	-	-	-	-	-	-	-	-	0.2	0.2	1	R
Zygorrhynchus moelleri	0.6	0.8	0.2	0.2	2.2	-	-	-	-	-	-	1.4	5.4	6	M
Total CFUs	9.2	5.4	10.4	2.6	8.8	5.6	3.6	9.8	7.6	6.4	53.0	11.8	134.2	12	H
No. of genera (11)	7	5	7	5	7	5	4	4	4	3	3	8	-	-	-
No. of species (39)	8	8	13	7	9	8	7	9	7	9	9	12	-	-	-

* Secondary effluent (after secondary treatment)

Table (7): Monthly average total counts (CFU/ml) of fungi in the fifth step* of wastewater treatment during the study period

Species \ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	T.C	NCI	O.R
Aspergillus japonicus	-	-	-	0.2	-	-	-	-	-	-	-	-	0.2	1	R
A. asperescens	-	-	-	-	-	-	-	-	-	-	2.8	-	2.8	1	R
A. flavipes	0.2	-	-	-	-	-	-	-	-	-	-	0.2	0.4	2	L
A. flavus	0.8	0.4	-	-	0.6	1.0	-	-	-	-	-	-	2.8	4	M
A. fumigatus	0.4	-	0.2	-	-	0.6	-	-	-	-	-	-	1.2	3	L
A. niger	-	0.4	0.4	-	0.8	-	-	-	-	0.4	-	-	2.0	4	M
A. niveus	-	-	-	-	-	-	-	3.2	-	-	-	-	3.2	1	R
A. ochraceus	-	-	-	-	-	-	-	1.6	-	0.2	-	2.0	3.8	3	L
A. oryzae	0.2	-	-	-	-	-	1.4	-	0.6	-	-	1.2	3.4	4	M
A. phoenicis	-	-	-	-	-	-	-	0.6	0.4	-	4.2	-	5.2	3	L
A. sulphureus	-	-	-	-	-	-	-	-	-	-	1.6	-	1.6	1	R
A. terricola	-	-	-	-	-	-	-	1.0	-	-	-	-	1.0	1	R
A. wentii	-	-	-	-	-	-	-	-	-	-	0.8	1.4	2.2	2	L
Fusarium lateritium	-	-	-	-	-	-	-	0.8	-	-	4.2	-	5.0	2	L
F. oxysporum	0.2	-	0.6	0.2	0.4	-	-	2.2	0.4	1.4	-	-	5.4	7	H
Geotrichum candidum	-	0.2	-	-	-	-	-	-	0.2	-	-	-	0.4	2	L
Mucor circinelloides	1.2	1.0	0.2	-	-	0.8	1.2	2.4	0.6	-	-	-	7.4	7	H
M. racemosus	-	-	-	-	-	-	-	-	-	-	1.2	3.0	4.2	2	L
Penicillium chrysogenum	-	0.6	0.2	-	-	-	-	0.2	-	-	-	-	1.0	3	L
P. commune	-	-	-	-	-	-	-	-	0.2	-	-	-	0.2	1	R
P. expansum	-	0.8	0.6	-	-	-	-	-	-	-	-	-	1.4	2	L
P. rubrum	-	-	0.4	-	-	-	-	-	-	-	-	-	0.4	1	R
P. velutinum	-	-	-	-	-	-	0.2	-	-	-	-	-	0.2	1	R
Rhizopus arrhizus	-	-	0.2	-	-	1.0	-	-	-	-	-	-	1.2	2	L
Syncephalastrum racemosum	-	-	-	-	-	-	0.4	-	-	-	-	-	0.4	1	R
Trichoderma harzianum	-	-	-	-	-	-	-	0.2	-	0.4	-	-	0.6	2	L
T. viride	-	-	-	-	-	-	-	-	-	-	-	0.2	0.2	1	R
Zygorrhynchus moelleri	0.2	0.2	0.2	-	0.2	-	-	-	-	-	-	0.4	1.2	5	M
Total CFUs	3.2	3.6	3.0	0.4	2.0	3.4	3.2	12.2	2.4	2.4	14.8	8.4	59.0	12	H
No. of genera (9)	4	5	6	2	3	3	4	5	5	3	3	4	-	-	-
No. of species (28)	7	7	9	2	4	4	4	9	6	4	6	7	-	-	-

* Final effluent (after chlorination)

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