STM 2016

by Andri Kurniawan

Submission date: 09-Sep-2021 01:24PM (UTC+0700)
Submission ID: 1644321151
File name: Andri_STM 2016.pdf (512.95K)
Word count: 5205
Character count: 28918

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Article · May 2016

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Research & Reviews: A Journal of Microbiology and Virology
ISSN: 2230-9853(online), ISSN: 2349-4360(print)
Volume 6, Issue 1
www.stmjournals.com

Microorganism Communities Response of Ecological Changes in Post Tin Mining Ponds

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Abstract

The ecological changes are the main problem of post tin mining activities, such as post tin mining ponds and it has occurred for a long time chronosequence. The understanding of how post tin mining activities bring ecological changes and how the microorganism communities respond to these environment changes becomes an important part to explore the potential of bioremediator to accelerate the recovery of water quality as water sources for secondary activities and habitable for organisms and further, to determine the next aquatic ecosystem management. The change of ecological factors such as pH, dissolved oxygen (DO), and heavy metals can be focused for a discussion as affecting factors for changes in microorganism communities. In fact, all of the three factors can drive the alteration of microecosystem and indirectly causes change in microorganism communities. However, the survival capability of microorganisms, resistance and resilience capacity, and the interaction of microorganisms with ecosystem change, in particular, in post tin mining ponds chronosequence has not been explained properly.

Keywords:*post tin mining, ecological change, chronosequence, microorganisms*

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INTRODUCTION

Tin mining was one of mining activities that contribute to heavy metals contamination and environmental problems. In Heipang District of BarkinLadi of Nigeria, heavy metals were detected with very high concentrations of Pb, Zn, Mn, Fe, Cr, and Cu and also Ni in surface soil, soil, and sediment [1]; in the sediments of former tin mining catchment Bestari Jaya of Peninsular Malaysia was detected Sn, Pb, Zn, Cr, Cu, and As [2]; in post tin mining of Bangka Island of Indonesia was detected Fe, Al, Pb, Cu, and Zn [3, 4].

Furthermore, tin mining activities can also cause ecological problems such as temperature change, land degradation consequence, structure and composition of sand, clay, nitrogen, organic carbon, pH, cation exchange capacity (CEC), metal, etc [5–8]. Indirectly tin mining has changed the ecosystem and organism communities structure including an impact on microclimate in microscopic habitats and microorganisms's life [9].

Tin mining activity in land area was done by soil excavation; and soil formation was the result of a complex network of biological process as well as chemical and physical processes. The ecological consequence of tin mining activity was a degradation of soil composition, structure, quality, and physical or biological characteristics, erosion damages to land use or land cover, and changes of macro and microorganisms in their natural habitats [10–14]. The changes of microorganism communities in their habitat could have significant effect on ecosystem function [15] and also on abundance, diversity, and productivity of macro communities living there [16–18].

Post tin mining microecosystem with nutrients deficiencies, acidic pH, low dissolved oxygen (DO), metal oxidizing and the other extreme environmental factors can be uninhabitable for most microorganisms. However, few studies investigated the microorganism's life during ecological change process [19] or microbial succession pattern in change through time [20]. Few studies on post tin mining, in particular, only investigated diversity of methane-oxidizing bacteria (MOB) and ammonia-oxidizing bacteria (AOB) in disused ponds of post tin mining [21, 22]. While, an understanding of microorganisms and their activity as biological indicator of the contaminated ecosystem was crucial in order to predict ecosystem conditions and detect environment changes [23, 24] because they have a capability to respond quickly to the alterations, including in soil and aquatic ecosystem [25, 17].

Therefore, this review aims to gather information about the ecological changes that occur as a result of mining activities, especially in disused pond of post tin mining and to explain how the microorganism communities respond to the environmental changes caused by the tin mining chronosequence. The understanding of microbial adaptation capacity in post tin mining, particularly, in disused ponds of post tin mining and microorganisms' succession pattern for a long time effect of chronosequence becomes an important part to determine the next aquatic ecosystem management.

ECOLOGICAL CHANGE AND MICROORGANISM RESPONSE

Ecological Changes of Post Tin Mining

The increasing tin mining activity has produced various wastes such as tailings, oil, and fuel coming from the sand scraper tin boat [26]. Furthermore, heavy metals were detected from tin mining locations. In Malaysia, the tin mining activity has led to heavy metals contamination such as arsenic, copper, lead, tin and zinc in soil and then they were transferred to plants and it also happened for two shallow water aquatic plants [27] and heavy metals of tin mining was accumulated in different tissues and organs of organism, such as fish [28]. In the sediments of former tin mining catchment Bestari Jaya, Peninsular Malaysia indicated that the sediments have been polluted with arsenic (8.8%), chromium (12.9%), copper (17.4%), lead (19.5%), zinc (14.9%) and tin (33.8%) [2].

In additional to heavy metal, the characteristics of top soil samples from post tin mining area, Bestari Jaya, Peninsular Malaysia showed pH values ranging from acidic to neutral (4.8–7.2) [29]. The soils of post tin mining land generally had low CEC, organic matter, total nitrogen, available phosphorus, macronutrient and clay content in soil texture. The recovery of this condition to natural characteristics can be done by natural succession; however, development of natural succession even takes a very long time [30]. The effects of post tin mining contaminations also take place in aquatic ecosystem such as marine, river, and disused or reused post tin mining ponds.

The study of water quality and heavy metals in water of post mining area showed that there was variation in the environment [31]. Each water body has a pattern of physical and chemical characteristics which were determined largely by the climatic, geomorphological, and geochemical conditions prevailing in the drainage basin and the underlying aquifer [32]. As a reference, in Bangka Island of Indonesia, the study results showed contaminations of Fe was 2.48–8.17 mg/l, Al was 0.04–3.34 mg/l, Cu was < 0.002–0,14 mg/l, and Zn < 0.007–0.450 mg/l in Kolong Hijau (green pond). In Kolong TB 1.9 (TB pond 1.9), contaminations of Fe, Al, Cu, and Zn were 2,230–32,270 mg/l, 7,560–80,000 mg/l, 0,0–0,080 mg/l, dan 0,0–0,870 mg/l [4]. North Central Nigeria, also experienced similar problems of heavy metals contamination from tin mining.A manganese value of 0.9 mg/l which was higher than the World Health Organization (WHO) highest desirable level of 0.05 mg/l was recorded from a mine pond and chromium values of 0.1mg/l and 0.12 mg/l, respectively, which exceeded the maximum admissible concentration of 0.005 mg/l [33].

Microorganism Responseof Post Tin Mining Ecosystem

The changes in post tin mining ecosystems characteristic as well as in other ecosystems certainly followed the changes of the organisms including the structure of microbial communities [34]. Microorganisms like bacteria can adapt to various environmental factors by modifying their membranes, in particular, phospholipid fatty acids composition and interaction between proteins and lipids [35]. Phospholipids are essential membrane components that make up a relatively constant proportion of the microorganisms under natural conditions.Their patterns provide an insight into the structure of microorganism communities and biomass so they are used as one of the useful tool identifying microorganisms and characterizing microbial communities in natural systems [36].

Some factors, particularly, in aquatic ecosystem of post tin mining, can be focused for attention which might significantly influence the life of microorganisms there. As stated earlier, it is important to know the response of microorganisms to the ecological changes in post tin mining aquatic ecosystem and the response of microorganisms shown by their diversity and metabolic activity [37]. In principle, the succession of microorganisms in post tin mining have a similarity with the succession of microorganisms, generally, in others post mining.

However, the critical factors such as pH value, DO, and type of heavy metals can be focused as indicators in chronosequence study of microbial communities' response and succession.

Effect of pH Value on Microorganism Communities

pH value has been shown to be an important factor driving microbial communities [38]. As a reference, pH value of post tin mining water in Bangka Island in TB 1.9 (young post tin mining pond) was 2.21–3.42 and in Kolong Hijau (old post tin mining pond) was 4.82–6.48 [4]. pH value of post tin mining water was less than 7; therefore, post tin mining water can be characterized as acidic water.

Acidic pH and low DO are the characteristics of metal and sand mining activity [31]. Acidic waste waters from industrial and mining activities as acid mine drainage (AMD) waters were often highly acidic ($pH < 4$) [39]. Acid mine drainage was a result from the oxidization of sulfide minerals (principally pyrite, FeS_2), primarily via microbial-mediated reactions, after the mine wastes were exposed to oxygen and water [40]. Acidic, metal-rich waters generated by the microbial accelerated dissolution of pyrite and other sulfide minerals were frequently encountered in derelict mine sites, including many that have been long-abandoned [41].

Acidic water can eliminate alkaline-tolerant microorganism and some microorganism in neutral pH. However, acid-tolerant microorganism can survive and even microorganisms that have a pH optimum for growth of acidic pH termed as acidophiles consists of extreme acidophiles (pH 2.7 or pH <3) and moderate acidophiles (pH 5.7 or pH 3–5) [42, 43].

Acidophiles can accelerate dissolution of pyrite and other sulfide minerals in tailings as mineral waste generated by metal mining act as sources of acid [44]. They can generate energy by the conversion process of ferrous to ferric iron in acidic environment [45], and are psychrotolerant obligate autotrophs that appears to use only ferrous iron as an electron donor and oxygen as an electron acceptor [46].

To survive in acidic pH, acidophiles maintain a pH gradient of several pH units across the cellular membrane while producing ATP by the influx of protons through the F_0F_1 ATPase [47]. Some researchers have shown that pH value causes changes in microorganism (e.g. bacteria) composition, abundance, or diversity that Firmicutes, Actinobacteria, Gamma-Proteobacteria tend to dominant at pH 2.7, Acidobacteria are very dominant at pH 3 and pH 5.5, Firmicutes also dominant at pH 5.7, while Gamma-Proteobacteria are very dominant in alkaline condition (pH 10.3) (Figure 1).

Other studies also represented the effect of pH on diversity of microorganism communities [48]. The changes in structure of microorganism communities may occur in post tin mining pond with acidic to neutral pH value; however, a study is required to prove the same.

Effect of DO Value on Microorganism Communities

In addition to acid pH value, low DO selects microorganisms that can survive in the environment. In surface tailings water, communities detected were an unusual mixture of obligate aerobes, obligate anaerobes, and facultative anaerobes [51]. In post tin mining activity, MOB (the ϒ-proteobacterial and α-proteobacteria) and AOB were isolated from disused tin mining lakes [21, 22].

The microorganisms in post tin mining ponds can be identified as facultative anaerobic microorganisms because they can use oxygen for their activity such as methane and ammonia oxidation, but also may grow in the environment without oxygen or low oxygen concentration. In fact, the oxygen-depleted water of mining was dominated by acidophilic communities with chemolithotrophic facultative anaerobe properties [52]; the chemolithotrophic facultative anaerobe microorganism usually dominates all natural and man-made acidic environments. Acidophilic species has a mixotrophy strategy, as heterotrophic that uses organic compounds in the form of dissolved organic carbon (DOC) (chemoheterotroph) and as autotrophic that uses light, inorganic carbon, and mineral nutrients for photosynthesis (photoautotroph) [45].

The DO and DOC concentration can drive the microorganism (e.g. bacteria) diversity change. As a reference, the results in Figure 2 show that Aciditiobacillus, Leptospirilium, and Ferroplasma dominate in DO 3, 8 and 5; while Ferroplasma and Acidiphilium very dominant in DOC 6, 8 or low DO. The community structure change may also occur in post tin mining ponds with low oxygen concentration; although, a study needs to be undertaken for a justification.

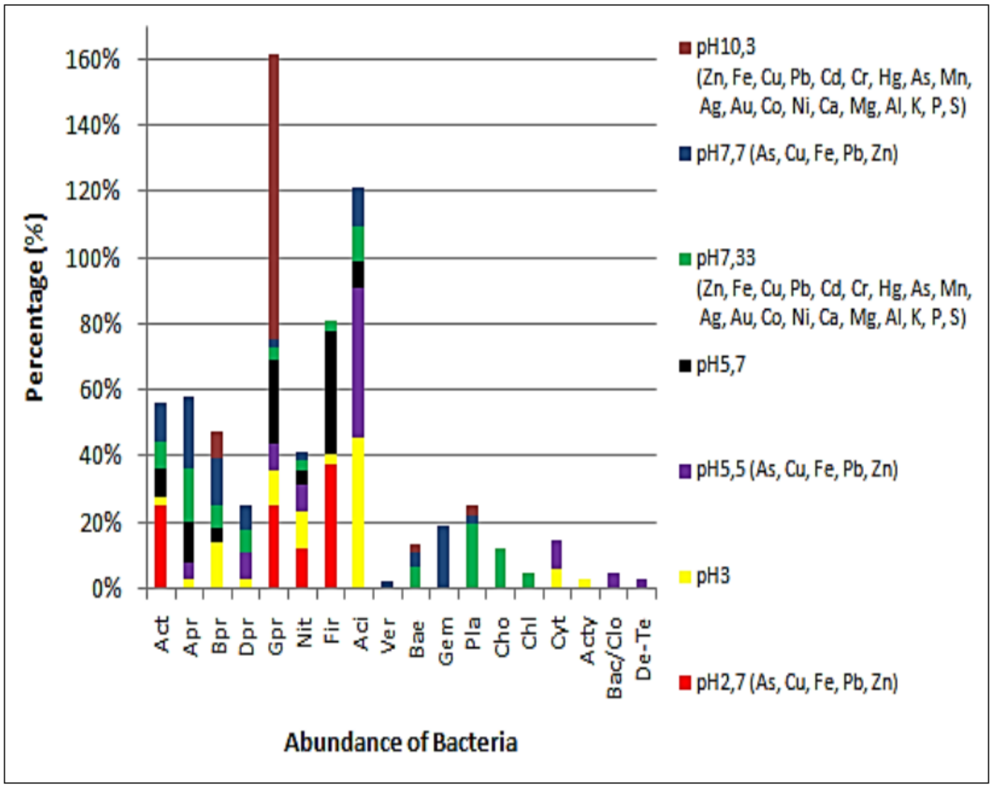

Fig. 1: *Abundance Relative of Bacteria Communities in Relation to pH Value and Heavy Metal. Act (Actinobacteria), Apr (Alpha-Proteobacteria), Bpr (Beta-Proteobacteria), Dpr (Delta-Proteobacteria), Gpr (Gamma-Proteobacteria), Nit (Nitrospira), Fir (Firmicutes), Aci (Acidobacteria), Ver (Verrucomicrobia), Bae (Bacteroidetes), Gem (Gemmatimonadetes), Pla (Planctomycetes), Cho (Choloflexi), Chl (Chlorobi), Cyt (Cytophagales), Acty (Actinomycetes), Bac/Clo (Bacillus/Clostridium), De-Te (Deinococcus-Termus) [43, 49,50].*

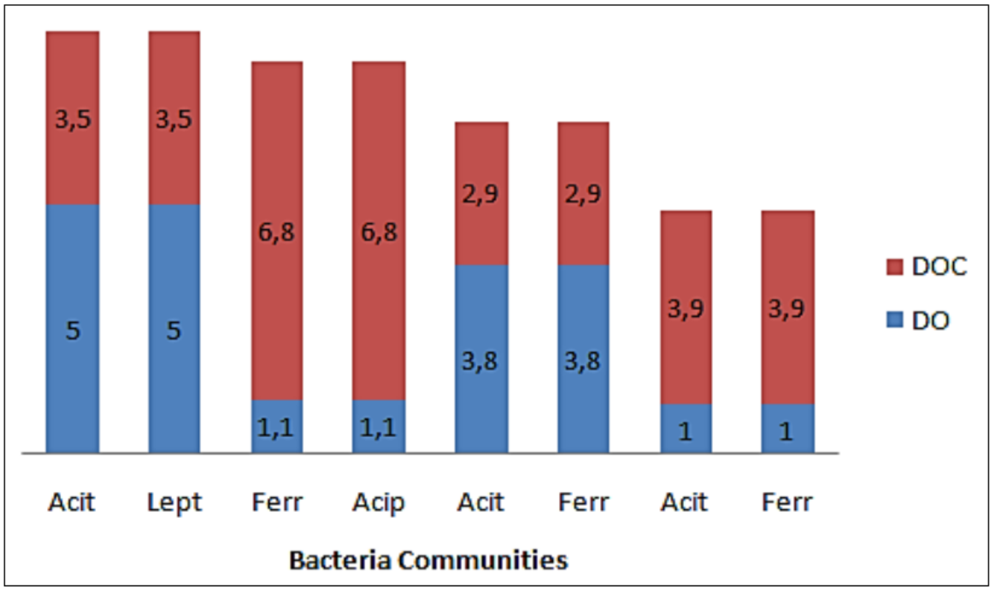

***Fig. 2**: The Dominant Bacteria Communities in Different DO and DOC, Based on 16S rRNA. Acit (Acidithiobacillus), Lept (Leptospirilium), Ferr (Ferroplasma), Acip (Acidiphilium) [53].*

Effect of Heavy Metal onMicroorganism Communities

Beside the pH and DO value, heavy metals are one of barrier factors for the growth of microorganisms. Metal concentration of water and soil are good indicators of degree of contamination [31]. The number of microorganisms depends on the total content and concentrations of particular form of heavy metals. Heavy metals can shift the structure of microbial populations, improverish their diversity, and affect species compositions, reproduction, and activity of indigenous microorganisms [54].

Pollution has a significant impact on structural and functional diversity of microbial communities [55], size and activity [56], composition of microbial communities, and diversity change along chemical gradients [57]. A significant correlation was found between the microorganism communities and geochemical factors, including heavy metal [58]. Therefore, only certain microorganisms can survive, tolerate, or resist heavy metal contamination by determining cellular responses and adaptive mechanisms [59]. The type and composition of heavy metals can drive a diversity of microorganisms [43, 49, 50]. The impact of heavy metal contamination on microorganism (e.g. bacteria) community is shown in Figure 1. Other studies also represent the effect of heavy metal on microorganism communities diversity [53, 60, 61], and the community structure change may also occur in post tin mining pond with low oxygen concentration. Although, a study is required for a justification.

These characteristics and metabolic abilities were used to adapt in contaminated ecosystem. The changes in microbial community structure were significantly related to the size of microbial biomass as well as numerous edaphic variables (including pH and C, N, and P nutrient concentrations) [62]. Microorganism communities can survive for a long ecosystem evolution because they have resistance (insensitivity to disturbance) and resilience (the rate of recovery after disturbance) [63] for C, N, sulfur cycling, and metal [64] higher than others.

They can also use some metals as micronutrients and for redox processes, to stabilize molecules through electrostatic interactions, as components of various enzymes, and for regulation of osmotic pressure. They remove the heavy metals by using chemicals for their growth and development. They are capable of dissolving metals and reducing or oxidizing transition metals. They have adapted to the presence of both nutrient and nonessential metals by developing a variety of biogeochemical mechanisms, such as exclusion by permeability barrier, intra- and extracellular sequestration, active transport efflux pumps, enzymatic detoxification, and reduction in the sensitivity of cellular targets to metal ions, translocation, transformation, chelation, immobilization, solubilization, precipitation, volatilization, and complexation of heavy metals [65–67].

CONCLUSIONS

Ecological changes such as presence of heavy metals, pH value, DO, and age of post mining ponds factors as a result of tin mining, particularly, in disused or post tin mining ponds predispose the structure of microorganism communities. Some studies have explained characteristics of post tin mining ponds and the microorganisms in disused tin mining ponds, including MOB and AOB. However, the survival capability of microorganisms, resistance and resilience capacity, and the interaction of microorganisms with ecosystem changes chronosequence has not been explained properly.

This review has collected information on ecological changes in disused ponds of post tin mining and response of microorganism communities on the changes chronosequencely. Further, advanced research is required about the effect of pH, DO, and heavy metals on abundance and diversity of microorganisms in post tin mining ponds, and also the consortium affectivity of bioremediator to remediate heavy metals in post tin mining pond so that it becomes a solution to accelerate the recovery of water sources for secondary activities and habitable for organisms.

ACKNOWLEDGMENTS

I would like to thank Prof. Agus Irianto, Ardhini Rin Maharning, Ph.D, and Suci Puspita Sari, M.Si who have assisted in the review.

REFERENCES

1. Daniel VN, Chudusu ES, Chup JA, *et al*. Variations of heavy metals in agricultural soils irrigated with tin water in Heipang District of BarkinLadi, Plateau State, Nigeria. *Int J SciTechnol*. 2014; 3(5): 255–63p.
2. Ashraf MA, Maah MJ, Yusoff I. Speciation of heavy metals in the sediments of former tin mining catchment. *Iran J SciTechnol*. 2012; (2012 A2): 163–80p.
3. Henny C. Bioakumulasi beberapa logam pada ikan di kolong bekas tambang timah di Pulau Bangka. *Limnotek*. 2011; 18(1): 83–95p.
4. Rosidah, Henny C. [Kajian logam Fe, Al, Cu dan Zn pada perairan kolong paska penambangan timah di Pulau Bangka]. *Proceedings of the National Seminar on Limnology VI*; 2012 July 16–17; Bogor, Indonesia.
5. Yinghong F, Zhaohua L, Jianlong C, *et al*. Major ecological and environmental problems and the ecological reconstruction technologies of the coal mining areas in China. *ActaEcologicaSinica*. 2003;23(10): 2144–52p.
6. Ashraf MA, Maah MJ, Yusoff I. Study of water quality and heavy metals in soil & water of ex-mining area Bestari Jaya, Peninsular Malaysia. *IJBAS-IJENS*. 2010; 10(3): 7–12p.
7. Ashraf MA, Maah MJ, Yusoff I. Chemical speciation and potential mobility of heavy metals in the soil of former tin mining catchment. *The Scientific World Journal*. 2012; 2012: 1–11p. DOI: 10.1100/2012/125608
8. Singh PK, Afzal I, Ravi S, *et al*. A study about ecological imbalance in Surguja (India) coalfield area due to mining. *Int Res J Environ Sci*.2013; 2(4): 10–14p.
9. Oladipo GO, Olayinka A, Awotoye OO. Ecological impact of mining on soils of Southwestern Nigeria. *Environ ExpBiol*. 2012; 12(2014): 179–86p.
10. Vyas A, Pancholi A. Environmental degradation due to mining in South Rajasthan: a case study of Nimbahera, Chittorgarh (India). *J Environ Res Develop*. 2009; 4(2): 405–12p.

11. Musa HD. An assessment of mining activities impact on vegetation in Bukuru Jos Plateau State Nigeria using normalized differential vegetation index (NDVI). *J Sustain Develop*. 2011; 4(6): 150–9p.
12. Ndace JS, Danladi MH. Impacts of derived tin mining activities on landuse/landcover in Bukuru, Plateau State, Nigeria. *J Sustain Develop*. 2012; 5(5): 90–100p.
13. Giri K, Mishra G, Pandey S, *et al*. Ecological degradation in northeastern coal fields: Margherita Assam. *Int J Sci Environ Technol*. 2014; 3(3): 881–4p.
14. Lad RJ, Samant JS. Impact of bauxite mining on soil: a case study of bauxite mines at Udgiri, Dist-Kolhapur, Maharashtra State, India. *Int Res J Environ Sci*. 2015; 4(2): 77–83p.
15. Classen AT, Sundqvist MK, Henning JA, *et al*. Direct and indirect effects of climate change on soil microbial and soil microbial-plant interactions: what lies ahead? *Ecosphere*. 2015; 6(8): 130p. DOI: 10.1890/es15-00217.1
16. Horz HP, Barbrook A, Field CB, *et al*. Ammonia-oxidizing bacteria respond to multifactorial global change. *PNAS*. 2004; 101(42): 15136–41p. DOI: 10.1073 pnas.040661610
17. Lau JA, Lennon JT. Rapid responses of soil microorganisms improve plant fitness in novel environments. *PNAS Early Edition*. 2012; 109(35): 14058–62p. DOI: 10.1073/pnas.1202319109
18. Schulz S, Brankatschk R, Dumig A, *et al*.The role of microorganisms at different stages of ecosystem development for soil formation. *Biogeosciences*. 2013; 10(2013): 3983–96p. DOI: 10.5194/bg-10-3983-2013
19. Yang L, Li X, Li X, *et al*. Microbial community dynamics during the Bioremediation Process of Chlorimuron-Ethyl-Contaminated Soil by *Hansschlegelia* sp. Strain CHL1. *PLoS ONE*. 2015; 10(2): 1–16p. DOI:10.1371/journal. pone.0117943
20. Fierer N, Nemergut D, Knight R, *et al*. Changes through time: integrating microorganisms into the study of succession. *Res Microbiol*. 2010; 161(8):635–42p. DOI:10.1016/j.resmic.2010.06.002
21. Sow SLS, Khoo G, Chong LK, *et al*. Molecular diversity of the ammonia-oxidizing bacteria community in disused tin-mining ponds located within Kampar, Perak, Malaysia. *World J Microbiol Biotechnol*. 2014; 30(2): 757–66p.
22. Sow SLS, Khoo G, Chong LK, *et al*. Molecular diversity of the methanotrophic bacteria communities associated with disused tin-mining ponds in Kampar, Perak, Malaysia. *World J Microbiol Biotechnol*. 2014; 30(2014): 2645–53p. DOI:10.1007/s11274-014-1687-z
23. Niemi GJ, McDonald ME. Application of ecological indicators. *Annu Rev EcolEvolSyst*. 2004;35(2004):89–111p. DOI:10.1146/annurev.ecolsys.35.112202.130132
24. Moscatelli MC, Lagomarsino A, Marinari S, *et al*. Soil microbial indices as bioindicators of environmental changes in a poplar plantation. *Ecological Indicators*. 2005; 5(3): 171–9p. DOI:10.1016/j.ecolind.2005.03.002
25. Paerl HW, Dyble J, Moisander PH, *et al*. Microbial indicators of aquatic ecosystem change: current applications to eutrophication studies. *FEMS Microbiol Ecol*. 2003; 46(2003): 233–46p. DOI:10.1016/S0168-6496(03)00200-9
26. Ahmad F. Distribusi dan prediksi tingkat pencemaran logam berat (Pb, Cd, Cu, Zn, dan Ni) dalam sedimen di perairan Pulau Bangka menggunakan indeks beban pencemaran dan indeks geoakumulasi. *Jurnal Ilmu dan Teknologi Kelautan Tropis*. 2013; 5(1): 170–81p.
27. Ashraf MA, Maah MJ, Yusoff I. Heavy metals accumulation in plants growing in ex tin mining catchment. *Int J Environ Sci Tech*. 2011; 8(2): 401–16p.
28. Ahmad AK, Al-Mahaqeri SA. Human health risk assessment of heavy metals in fish species collected from catchments of former tin mining. *IJRSSET*. 2015; 2(4): 9–21p.
29. Ashraf MA, Maah MJ, Yusoff I. Evaluation of natural phytoremediation process occurring at ex-tin mining catchment. *Chiang Mai J Sci*.2013; 40(2): 198–213p.

30. Oktavia D, Setiadi Y, Hilwan I.Sifat fisika dan kimia tanah di hutan kerangas dan lahan pasca tambang timah Kabupaten Belitung Timur. *Jurnal Silvikultur Tropika*. 2014; 5(3): 149–54p.
31. Ashraf MA, Maah MJ, Yusoff I. Analysis of physio-chemical parameters and distribution of heavy metals insoil and water of ex-mining area of Bestari Jaya, Peninsular Malaysia. *Asian J Chem*. 2011; 23(8): 3493–9p.
32. Ashraf MA, Maah MJ, Yusoff I. Morphology, geology and water quality assessment of former tin mining catchment. *The Scientific World Journal*. 2012; 2012: 1–15p. DOI: 10.1100/2012/369206
33. Gyang JD, Ashano EC. Effects of mining on water quality and the environment: a case study of parts of the Jos Plateau, North Central Nigeria. *Pac J Sci Technol*. 2010; 11(1): 631–9p.
34. Grant RJ, Muckian LM, Clipson NJ, *et al*. Microbial community changes during the bioremediation of creosote-contaminated soil. *Lett Appl Microbiol*. 2007; 44(3): 293–300p.
35. Mrozik A, Piotrowska-Seget Z, Łabużek S. Cytoplasmatic bacterial membrane responses to environmental perturbations. *Polish J Environ Stud*. 2004; 13(5): 487–94p.
36. Piotrowska-Seget Z, Mrozik. Signature Lipid Biomarker (SLB) analysis in determining changes in community structure of soil microorganisms. *Polish J Environ Stud*. 2003; 12(6): 669–75p.
37. Tomkiel M, Wyszkowska J, Kucharski J, *et al*. Response of microorganisms and enzymes to soil contamination with the herbicide successor T 550 SE. *Environment Protection Engineering*. 2014; 40(4): 15–27p. DOI: 10.5277/epe140402
38. Kuramae E, Gamper H, Veen JV, *et al*. Soil and plant factors driving the community of soil-borne microorganisms across chronosequences of secondary succession of chalk grasslands with a neutral pH. *FEMS Microbiol Ecol*. 2011; 77(2011): 285–94p.
39. Kolmert A, Johnson DB. Remediation of acidic waste waters using immobilised, acidophilic sulfate-reducing bacteria. *Chem Technol Biotechnol*. 2001; 76(8): 836–43p.
40. Tan G, Shu W, Hallberg KB, *et al*. Cultivation-dependent and cultivation-independent characterization of the microbial community in acid mine drainage associated with acidic Pb/Zn mine tailings at Lechang, Guangdong, China. *FEMS Microbiol Ecol*. 2007; 59(2007): 118–26p. DOI: 10.1111/j.1574-6941.2006.00216.x
41. Johnson DB, Hallberg KB. Mini-review: the microbiology of acidic mine waters. *Res Microbiol*. 2003; 154(7): 466–73p.
42. Johnson DB, Hallberg KB. Carbon, iron and sulfur metabolism in acidophilic micro-organisms. *Adv Microb Physiol*. 2008; 54(2008): 201–55p. DOI: 10.1016/S0065-2911(08)00003-9
43. Mendez MO, Neilson JW, Maier RM. Characterization of a bacterial community in an abandoned semiarid lead-zinc mine tailing site. *Appl Environ Microbiol*. 2008; 74(12): 3899–907p. DOI: 10.1128/aem.02883-07
44. Nancucheo I, Johnson DB. Significance of microbial communities and interactions in safeguarding reactive mine tailings by ecological engineering. *Appl Environ Microbiol*. 2011; 77(23): 8201–8p. DOI: 10.1128/aem.06155-11
45. Hao C, Wang L, Gao Y, *et al*. Microbial diversity in acid mine drainage of Xiang Mountain sulfide mine, Anhui Province, China. *Extremophiles*. 2010; 14(2010): 465–74p. DOI: 10.1007/s00792-010-0324-5
46. Johnson DB, Hallberg KB, HedrichS. Uncovering a microbial enigma: isolation and characterization of the streamer-generating, iron-oxidizing, acidophilic bacterium "*Ferrovummyxofaciens*". *Appl Environ Microbiol*. 2014; 80(2): 672–80p. DOI: 10.1128/aem.03230-13
47. Baker-Austin C, Dopson M. Life in acid: pH homeostasis in acidophiles. *Trends Microbiol*. 2007; 15(4): 165–71p. DOI:10.1016/j.tim.2007.02.005
48. Kuang J, Huang L, Chen L, *et al*. Contemporary environmental variation determines microbial diversity patterns in acid mine drainage. *The ISME Journal*. 2013; 7(2013): 1038–50p.

49. Blo¨the M, Akob DM, Kostka JE, *et al*. pH gradient-induced heterogeneity of Fe(III)-reducing microorganisms in coal mining-associated lake sediments. *Appl Environ Microbiol*. 2008; 74(4): 1019–29p. DOI: 10.1128/aem.01194-07
50. Xie X, Zhu W, Liu N, *et al*. Bacterial community composition in reclaimed and unreclaimed tailings of Dexing copper mine, China. *Afr J Biotechnol*. 2007; 12(30): 4841–9p. DOI: 10.5897/ajb12.2549
51. Saidi-Mehrabad A, He Z, Tamas I, *et al*. Methanotrophic bacteria in oilsands tailings ponds of Northern Alberta. *The ISME Journal*. 2013; 7(2013): 908–21p.
52. Rowe OF, Sanchez-Espana J, Hallberg KB, *et al*. Microbial communities and geochemical dynamics in an extremly acid, metal-rich stream at an abandoned sulfide mine (Huelva Spain) underpinned by two fuctional primary production systems. *Environ Microbiol*. 2007;9(7): 1761–71p. DOI: 10.1111/j.1462-2920.2007.01294.x
53. Chen L, Min Hu, Huang L, *et al*. Comparative metagenomic and metatranscriptomic analyses of microbial communities in acid mine drainage. *The ISME Journal*. 2015; 9(2015): 1579–92p.
54. Sa'idi M. Experimental studies on effect of heavy metals presence in industrial wastewater on biological treatment. *Int J Environ Sci*. 2010; 1(4): 666–76p.
55. Liao M, Xie XM. Effect of heavy metals on substrate utilization pattern, biomass, and activity of microbial communities in a reclaimed mining wasteland of red soil area. *Ecotox Environ Safe*. 2007; 66(2): 217–23p.
56. Wang YP, Shi JY, Wang H, *et al*. The influence of soil heavy metals pollution on soil microbial biomass, enzyme activity, and community composition near a copper smelter. *Ecotox Environ Safe*. 2007; 67(1): 75–81p. DOI: 10.1016/j.ecoenv.2006.03.007
57. Bier RL, Voss KA, Bernhardt ES. Bacterial community responses to a gradient of alkaline mountaintop mine drainage in Central Appalachian streams. *ISME J*. 2015; 9(6): 1378–90p. DOI: 10.1038/ismej.2014.222.
58. Vishnivetskaya AT, Mosher JJ, Palumbo AV, *et al*. Mercury and other heavy metals influence bacterial community structure in contaminated Tennessee streams. *Appl Environ Microbiol*. 2011; 77(1): 302–11p. DOI: 10.1128/aem.01715-10
59. Schmidt A, Haferburg G, Sineriz M, *et al*. Heavy metal resistance mechanisms in Actinobacteria for survival in AMD contaminated soils. *Chemie der Erde*. 2005; 65(2005) S1: 131–44p. DOI: 10.1016/j.chemer.2005.06.006
60. Zhang H, Shi W, Yang M, *et al*. Bacterial diversity at different depths in lead-zinc mine tailings as revealed by 16S rRNA gene libraries. *J Microbiol*. 2007; 45(6): 479–84p.
61. Yang Y, Shi W, Wan M, *et al*. Diversity of bacterial communities in acid mine drainage from the Shen-bu copper mine, Gansu province, China. *Electron J Biotechnol*. 2008; 11(1): 107–19p. DOI: 10.2225/vol11-issue1-fulltext-6
62. Banning NC, Gleeson DB, Grigg AH, *et al*. Soil microbial community successional patterns during forest ecosystem restoration. *Appl Environ Microbiol*. 2011; 77(17): 6158–64p. DOI: 10.1128/aem.00764-11
63. Shade A, Peter H, Allison SD, *et al*. Fundamentals of microbial community resistance and resilience. *Front Microbiol*. 2012; 3(417): 1–19p. DOI: 10.3389/fmicb.2012.004.17
64. Xie J, He Z, Liu X, *et al*. Geochip-based analysis of the functional gene diversity and metabolic potential of microbial communities in acid mine drainage.*Appl Environ Microbiol*. 2011; 77(3): 991–9p. DOI: 10.1128/aem.01798-10
65. Bruins MR, Kapil S, Oehme FW. Microbial resistance to metals in the environment. *Ecotox Environ Safe*. 2000;45(3): 198–207p.
66. Rajkumar M, Sandhya S, Prasad MNV, *et al*. Perspectives of plant-associated microbes in heavy metal phytoremediation. *Biotechnol Adv*. 2012; 30(6): 1562–74p. DOI: 10.1016/j/biotechadv.2012.04.001

67. Dixit R, Wasiullah, Malaviya D, *et al*. Bioremediation of heavy metals from soil and aquatic environment: an overview of principles and criteria of fundamental processes. *Sustainability*. 2015; 2015(7): 2189–212p. DOI:10.3390/su7022189

Cite this Article
Kurniawan A. Microorganism Communities Response of Ecological Changes in Post Tin Mining Ponds. *Research & Reviews: Journal of Microbiology and Virology*. 2016; 6(1): 17–26p.

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