Reinstating Microbial Diversity in Degraded Ecosystems for Enhancing Their Functioning and Sustainability

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Chapter
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Abstract

Biodiversity is the variety of life on earth, starting from genes, individual species, and communities to the whole ecosystems. The biodiversity and complex interaction networks of its components play a crucial role in regulating processes in different ecosystems' functioning and sustainability. Global biodiversity has been declining rapidly due to human impacts like land-use change, urbanization, environmental pollutions, and also the resultant climate change, leading to losing ecosystem functioning and sustainability. This chapter discusses the biodiversity, the causes of its degradation, and ways to reverse it. Interestingly, application of advanced microbial formulations to the soil has been shown to be capable of reinstating the lost biodiversity in agroecosystems. One such formulation is biofilm microbial ameliorators [BMAs, e.g., biofilm biofertilizers (BFBFs)]. Once applied to the soil, they break the dormancy of microbial seed bank formed to circumvent the stress of agricultural practices, thus re-establishing the biodiversity to a considerable extent for improved ecosystem functioning and sustainability. The same mechanism has been shown to be instrumental in environmental bioremediation. Fascinatingly, the potential of BMAs even in reinstating the biodiversity of disease-proven human gut microbiota has been reported for improved human health. It is also important to note that the past social impacts on decreasing biodiversity have now boomeranged to humans' existence. The application of microbial biotechnologies like developed BMAs could mitigate such devastating events in the future.

Keywords

Biodiversity Biofilms Health Sustainability

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References

Bandara WMMS, Seneviratne G, Kulasooriya SA (2006) Interactions among endophytic bacteria and fungi effects and potentials. J Biosci 31:645–650. https://doi.org/10.1007/BF02708417 (https://doi.org/10.1007/BF02708417)
CrossRef (https://doi.org/10.1007/BF02708417)
PubMed (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Abstract&list_uids=17301503)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Interactions%20among%20endophytic%20bacteria%20and%20fungi%20effects%20and%20potentials&author=WMMS.%20Bandara&author=G.%20Seneviratne&author=SA.%20Kulasooriya&journal=J%20Biosci&volume=31&pages=645-650&publication_year=2006&doi=10.1007%2FBF02708417)

Bruder A, Frainer A, Rota T, Primicerio R (2019) The importance of ecological networks in multiple-stressor research and management. Front Environ Sci 7:59. https://doi.org/10.3389/fenvs.2019.00059 (https://doi.org/10.3389/fenvs.2019.00059)
CrossRef (https://doi.org/10.3389/fenvs.2019.00059)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20importance%20of%20ecological%20networks%20in%20multiple-stressor%20research%20and%20management&author=A.%20Bruder&author=A.%20Frainer&author=T.%20Rota&author=R.%20Primicerio&journal=Front%20Environ%20Sci&volume=7&pages=59&publication_year=2019&doi=10.3389%2Ffenvs.2019.00059)

Brussaard L, De Ruiter PC, Brown GG (2007) Soil biodiversity for agricultural sustainability. Agric Ecosyst Environ 121:233–244
CrossRef (https://doi.org/10.1016/j.agee.2006.12.013)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Soil%20biodiversity%20for%20agricultural%20sustainability&author=L.%20Brussaard&author=PC.%20Ruiter&author=GG.%20Brown&journal=Agric%20Ecosyst%20Environ&volume=121&pages=233-244&publication_year=2007)

Buddhika UVA, Seneviratne G, Ekanayake MHGSE, Senanayake DMN, Igalavithane AD, Weeraratne N, Jayasekara APDA, Weerakoon WL, Indrajith A, Gunaratne HMAC, Kumara RKGK, De Silva MSDL, Kennedy IR (2016) Biofilmed biofertilizers: application in agroecosystems. In: Gupta VK, Thangdurai D, Sharma GD (eds) Microbial bioresources. CAB International, Wallingford, pp 96–106
CrossRef (https://doi.org/10.1079/9781780645216.0096)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Biofilmed%20biofertilizers%3A%20application%20in%20agroecosystems&author=UVA.%20Buddhika&author=G.%20Seneviratne&author=MHGSE.%20Ekanayake&author=DMN.%20Senanayake&author=AD.%20Igalavithane&author=N.%20Weeraratne&author=APDA.%20Jayasekara&author=WL.%20Weerakoon&author=A.%20Indrajith&au

thor=HMAC.%20Gunaratne&author=RKGK.%20Kumara&author=MSDL.%20Silva&author=IR.%20Kennedy&pages=96-106&publication_year=2016)

Bunning S, Jiménez JJ (2003) March indicators and assessment of soil biodiversity/soil ecosystem functioning for farmers and governments. In: Proceedings of OECD expert meeting on soil erosion and soil biodiversity indicators. OECD, Rome, pp 1–16
Google Scholar (http://scholar.google.com/scholar_lookup?title=March%20indicators%20and%20assessment%20of%20soil%20biodiversity%2Fsoil%20ecosystem%20functioning%20for%20farmers%20and%20governments&author=S.%20Bunning&author=JJ.%20Jim%C3%A9nez&pages=1-16&publication_year=2003)

De Silva MSDL, Jayasekera APDA, Seneviratne G, Abeysekera UP, Premathunga EWTP, Wijesekera SN (2014) Soil fertility improvement through biofilmed biofertilizers: potential for field applications in tea cultivations. Sri Lanka J Tea Sci 79:46–61
Google Scholar (http://scholar.google.com/scholar_lookup?title=Soil%20fertility%20improvement%20through%20biofilmed%20biofertilizers%3A%20potential%20for%20field%20applications%20in%20tea%20cultivations&author=MSDL.%20Silva&author=APDA.%20Jayasekera&author=G.%20Seneviratne&author=UP.%20Abeysekera&author=EWTP.%20Premathunga&author=SN.%20Wijesekera&journal=Sri%20Lanka%20J%20Tea%20Sci&volume=79&pages=46-61&publication_year=2014)

Decho AW (2000) Microbial biofilms in intertidal systems: an overview. Cont Shelf Res 20:1257–1273
CrossRef (https://doi.org/10.1016/S0278-4343(00)00022-4)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Microbial%20biofilms%20in%20intertidal%20systems%3A%20an%20overview&author=AW.%20Decho&journal=Cont%20Shelf%20Res&volume=20&pages=1257-1273&publication_year=2000)

He M, Petoukhov S (2011) Mathematics of bioinformatics: theory, methods and applications. John Wiley & Sons, New Jersey
Google Scholar (http://scholar.google.com/scholar_lookup?title=Mathematics%20of%20bioinformatics%3A%20theory%2C%20methods%20and%20applications&author=M.%20He&author=S.%20Petoukhov&publication_year=2011)

Herath L, Seneviratne G, Jayasinghe JAWW, Senanayake DMN (2017) Microbial biofilms and mitigation of loss of agro-biodiversity in degraded soils. J Natl Sci Found Sri Lanka 45:329–335
CrossRef (https://doi.org/10.4038/jnsfsr.v45i4.8226)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Microbial%20biofilms%20and%20mitigation%20of%20loss%20of%20agro-biodiversity%20in%20degraded%20soils&author=L.%20Herath&author=G.%20Seneviratne&author=JAWW.%20Jayasinghe&author=DMN.%20Senanayake&journal=J%20Natl%20Sci%20Found%20Sri%20Lanka&volume=45&pages=329-335&publication_year=2017)

Kulasooriya SA, Seneviratne G, Ekanayake EMHGS (2017) Soil microbial diversity and its utilization in agriculture in Sri Lanka. In: Patra JK, Vishnuprasad CN, Das G (eds) Microbial biotechnology. Springer Nature, Singapore, pp 203–224
CrossRef (https://doi.org/10.1007/978-981-10-6847-8_9)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Soil%20microbial%20diversity%20and%20its%20utilization%20in%20agriculture

%20in%20Sri%20Lanka&author=SA.%20Kulasooriya&author=G.%20Seneviratne&author=EMHGS.%20Ekanayake&pages=203-224&publication_year=2017)

Kumar A, Bisht BS, Joshi VD, Dhewa T (2011) Review on bioremediation of polluted environment: a management tool. Int J Environ Sci 1:1079–1083
Google Scholar (http://scholar.google.com/scholar_lookup?title=Review%20on%20bioremediation%20of%20polluted%20environment%3A%20a%20management%20tool&author=A.%20Kumar&author=BS.%20Bisht&author=VD.%20Joshi&author=T.%20Dhewa&journal=Int%20J%20Environ%20Sci&volume=1&pages=1079-1083&publication_year=2011)

Lata R, Chowdhury S, Gond SK, White JF Jr (2018) Induction of abiotic stress tolerance in plants by endophytic microbes. Lett Appl Microbiol 66:268–276
CrossRef (https://doi.org/10.1111/lam.12855)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Induction%20of%20abiotic%20stress%20tolerance%20in%20plants%20by%20endophytic%20microbes&author=R.%20Lata&author=S.%20Chowdhury&author=SK.%20Gond&author=JF.%20White&journal=Lett%20Appl%20Microbiol&volume=66&pages=268-276&publication_year=2018)

Lavelle P (1996) Diversity of soil fauna and ecosystem function. Biol Int 33:3–16
Google Scholar (http://scholar.google.com/scholar_lookup?title=Diversity%20of%20soil%20fauna%20and%20ecosystem%20function&author=P.%20Lavelle&journal=Biol%20Int&volume=33&pages=3-16&publication_year=1996)

Lupatini M, Suleiman AK, Jacques RJ, Antoniolli ZI, de Siqueira FA, Kuramae EE, Roesch LF (2014) Network topology reveals high connectance levels and few key microbial genera within soils. Front Environ Sci 2:10. https://doi.org/10.3389/fenvs.2014.00010 (https://doi.org/10.3389/fenvs.2014.00010)
CrossRef (https://doi.org/10.3389/fenvs.2014.00010)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Network%20topology%20reveals%20high%20connectance%20levels%20and%20few%20key%20microbial%20genera%20within%20soils&author=M.%20Lupatini&author=AK.%20Suleiman&author=RJ.%20Jacques&author=ZI.%20Antoniolli&author=FA.%20Siqueira&author=EE.%20Kuramae&author=LF.%20Roesch&journal=Front%20Environ%20Sci&volume=2&pages=10&publication_year=2014&doi=10.3389%2Ffenvs.2014.00010)

Maitima JM, Mugatha SM, Reid RS, Gachimbi LN, Majule A, Lyaruu H, Pomery D, Mathai S, Mugisha S (2009) The linkages between land use change, land degradation and biodiversity across East Africa. Afr J Environ Sci Technol 3:310–325
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20linkages%20between%20land%20use%20change%2C%20land%20degradation%20and%20biodiversity%20across%20East%20Africa&author=JM.%20Maitima&author=SM.%20Mugatha&author=RS.%20Reid&author=LN.%20Gachimbi&author=A.%20Majule&author=H.%20Lyaruu&author=D.%20Pomery&author=S.%20Mathai&author=S.%20Mugisha&journal=Afr%20J%20Environ%20Sci%20Technol&volume=3&pages=310-325&publication_year=2009)

Mangan SA, Schnitzer SA, Herre EA, Mack KM, Valencia MC, Sanchez EI, Bever JD (2010) Negative plant–soil feedback predicts tree-species relative abundance in a tropical forest. Nature 466:752–755
CrossRef (https://doi.org/10.1038/nature09273)

Google Scholar (http://scholar.google.com/scholar_lookup?title=Negative%20plant%E2%80%93soil%20feedback%20predicts%20tree-species%20relative%20abundance%20in%20a%20tropical%20forest&author=SA.%20Mangan&author=SA.%20Schnitzer&author=EA.%20Herre&author=KM.%20Mack&author=MC.%20Valencia&author=EI.%20Sanchez&author=JD.%20Bever&journal=Nature&volume=466&pages=752-755&publication_year=2010)

Nduka JKC, Orisakwe OE, Ezenweke LO, Ezenwa TE, ChendoMN ENG (2008) Acid rain phenomenon in Niger delta region of Nigeria: economic, biodiversity, and public health concern. Sci World J 8:811–818
CrossRef (https://doi.org/10.1100/tsw.2008.47)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Acid%20rain%20phenomenon%20in%20Niger%20delta%20region%20of%20Nigeria%3A%20economic%2C%20biodiversity%2C%20and%20public%20health%20concern&author=JKC.%20Nduka&author=OE.%20Orisakwe&author=LO.%20Ezenweke&author=TE.%20Ezenwa&author=ENG.%20ChendoMN&journal=Sci%20World%20J&volume=8&pages=811-818&publication_year=2008)

Patel I, Patel V, Thakkar A, Kothari V (2014) Microbial biofilms: microbes in social mode. Int J Agric Food Res 3:34–49
Google Scholar (http://scholar.google.com/scholar_lookup?title=Microbial%20biofilms%3A%20microbes%20in%20social%20mode&author=I.%20Patel&author=V.%20Patel&author=A.%20Thakkar&author=V.%20Kothari&journal=Int%20J%20Agric%20Food%20Res&volume=3&pages=34-49&publication_year=2014)

Plaas E, Meyer-Wolfarth F, Banse M, Bengtsson J, Bergmann H, Faber J, Potthoff M, Runge T, Schrader S, Taylor A (2019) Towards valuation of biodiversity in agricultural soils: a case for earthworms. Ecol Econ 15:291–300
CrossRef (https://doi.org/10.1016/j.ecolecon.2019.02.003)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Towards%20valuation%20of%20biodiversity%20in%20agricultural%20soils%3A%20a%20case%20for%20earthworms&author=E.%20Plaas&author=F.%20Meyer-Wolfarth&author=M.%20Banse&author=J.%20Bengtsson&author=H.%20Bergmann&author=J.%20Faber&author=M.%20Potthoff&author=T.%20Runge&author=S.%20Schrader&author=A.%20Taylor&journal=Ecol%20Econ&volume=15&pages=291-300&publication_year=2019)

Premarathna M (2019) Modified human microbiome towards better health. J Brief Ideas. https://doi.org/10.5281/zenodo.3445543 (https://doi.org/10.5281/zenodo.3445543)

Prescott LM, Harley JP, Klein DA (2002) Microbiology, 5th edn. McGraw Hill, New York
Google Scholar (http://scholar.google.com/scholar_lookup?title=Microbiology&author=LM.%20Prescott&author=JP.%20Harley&author=DA.%20Klein&publication_year=2002)

Sasikumar SC, Papinazath T (2003). Environmental management-bioremediation of polluted environment. In: Martin J, Bunch V, Suresh M, Kumaran TV (eds) Proceedings of the third international conference on environment and health, Chennai, India. Department of Geography, University of Madras and Faculty of Environmental Studies, York University, pp 465–469
Google Scholar (https://scholar.google.com/scholar?q=Sasikumar%20SC%2C%20Papinazath%20T%20%282003%29.%20Environmental%20management-bioremediation%20of%20polluted%20environment.%20In%3A%20Martin%20J%2C%2

0Bunch%20V%2C%20Suresh%20M%2C%20Kumaran%20TV%20%28eds%29%20Proceedings%20of%20the%20third%20international%20conference%20on%20environment%20and%20health%2C%20Chennai%2C%20India.%20Department%20of%20Geography%2C%20University%20of%20Madras%20and%20Faculty%20of%20Environmental%20Studies%2C%20York%20University%2C%20pp%20465%E2%80%93469)

Sato M, Tsuda K, Wang L, Coller J, Watanabe Y, Glazebrook J, Katagiri F (2010) Network modeling reveals prevalent negative regulatory relationships between signaling sectors in Arabidopsis immune signaling. PLoS Pathog 6(7):e1001011. https://doi.org/10.1371/journal.ppat.1001011 (https://doi.org/10.1371/journal.ppat.1001011)
CrossRef (https://doi.org/10.1371/journal.ppat.1001011)
PubMed (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Abstract&list_uids=20661428)
PubMedCentral (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2908620)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Network%20modeling%20reveals%20prevalent%20negative%20regulatory%20relationships%20between%20signaling%20sectors%20in%20Arabidopsis%20immune%20signaling&author=M.%20Sato&author=K.%20Tsuda&author=L.%20Wang&author=J.%20Coller&author=Y.%20Watanabe&author=J.%20Glazebrook&author=F.%20Katagiri&journal=PLoS%20Pathog&volume=6&issue=7&pages=e1001011&publication_year=2010&doi=10.1371%2Fjournal.ppat.1001011)

Seneviratne G (2020) Microbes govern the world: their adverse effects like current COVID-19 outbreak can only be addressed again by microbial interventions. ResearchGate. https://doi.org/10.13140/RG.2.2.14494.08006 (https://doi.org/10.13140/RG.2.2.14494.08006)

Seneviratne G, Jayasinghearachchi HS (2003) Mycelial colonization by bradyrhizobia and azorhizobia. J Biosci 28:243–247
CrossRef (https://doi.org/10.1007/BF02706224)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Mycelial%20colonization%20by%20bradyrhizobia%20and%20azorhizobia&author=G.%20Seneviratne&author=HS.%20Jayasinghearachchi&journal=J%20Biosci&volume=28&pages=243-247&publication_year=2003)

Seneviratne G, Jayasinghearachchi HS (2005) A rhizobial biofilm with nitrogenase activity alters nutrient availability in a soil. Soil Biol Biochem 37:1975–1197
CrossRef (https://doi.org/10.1016/j.soilbio.2005.02.027)
Google Scholar (http://scholar.google.com/scholar_lookup?title=A%20rhizobial%20biofilm%20with%20nitrogenase%20activity%20alters%20nutrient%20availability%20in%20a%20soil&author=G.%20Seneviratne&author=HS.%20Jayasinghearachchi&journal=Soil%20Biol%20Biochem&volume=37&pages=1975-1197&publication_year=2005)

Seneviratne G, Kulasooriya SA (2013) Reinstating soil microbial diversity in agroecosystems: the need of the hour for sustainability and health. Agric Ecosyst Environ 164:181–182
CrossRef (https://doi.org/10.1016/j.agee.2012.10.002)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Reinstating%20soil%20microbial%20diversity%20in%20agroecosystems%3A%20the%20need%20of%20the%20hour%20for%20sustainability%20and%20health&author

=G.%20Seneviratne&author=SA.%20Kulasooriya&journal=Agric%20Ecosyst%20Environ&volume=164&pages=181-182&publication_year=2013)

Seneviratne G, Premarathna M (2020) Biofilm medicines: next-generation drugs. ResearchGate. https://doi.org/10.13140/RG.2.2.24088.14081 (https://doi.org/10.13140/RG.2.2.24088.14081)

Seneviratne G, Zavahir JS, Bandara WMMS, Weerasekara MLMAW (2008) Fungal-bacterial biofilms: their development for novel biotechnological applications. World J Microbiol Biotechnol 24:739–743
CrossRef (https://doi.org/10.1007/s11274-007-9539-8)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Fungal-bacterial%20biofilms%3A%20their%20development%20for%20novel%20biotechnological%20applications&author=G.%20Seneviratne&author=JS.%20Zavahir&author=WMMS.%20Bandara&author=MLMAW.%20Weerasekara&journal=World%20J%20Microbiol%20Biotechnol&volume=24&pages=739-743&publication_year=2008)

Seneviratne G, Thilakaratne RMMS, Jayasekara KACN, Padmathilake KRE, De Silva MSDL (2009) Developing beneficial microbial biofilms on roots of non-legumes: a novel biofertilizer technique. In: Khan MS, Zaidi A, Mussarat J (eds) Microbial strategies for crop improvement. Springer-Verlag, Heidelberg, pp 51–61
CrossRef (https://doi.org/10.1007/978-3-642-01979-1_3)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Developing%20beneficial%20microbial%20biofilms%20on%20roots%20of%20non-legumes%3A%20a%20novel%20biofertilizer%20technique&author=G.%20Seneviratne&author=RMMS.%20Thilakaratne&author=KACN.%20Jayasekara&author=KRE.%20Padmathilake&author=MSDL.%20Silva&pages=51-61&publication_year=2009)

Seneviratne G, Weerasekara MLMAW, Seneviratne KACN, Zavahir JS, Kecskés ML, Kennedy IR (2010) Importance of biofilm formation in plant growth promoting rhizobacterial action. In: Maheshwari DK (ed) Plant growth and health promoting bacteria. Springer, New Delhi, pp 81–95
CrossRef (https://doi.org/10.1007/978-3-642-13612-2_4)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Importance%20of%20biofilm%20formation%20in%20plant%20growth%20promoting%20rhizobacterial%20action&author=G.%20Seneviratne&author=MLMAW.%20Weerasekara&author=KACN.%20Seneviratne&author=JS.%20Zavahir&author=ML.%20Kecsk%C3%A9s&author=IR.%20Kennedy&pages=81-95&publication_year=2010)

Seneviratne G, Weeraratne N, Buddhika UVA (2013) Diversity of plant root associated microbes: its regulation by introduced biofilms. In: Arora NK (ed) Plant microbe symbiosis—fundamentals and advances. Springer, New Delhi, pp 351–372
CrossRef (https://doi.org/10.1007/978-81-322-1287-4_13)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Diversity%20of%20plant%20root%20associated%20microbes%3A%20its%20regulation%20by%20introduced%20biofilms&author=G.%20Seneviratne&author=N.%20Weeraratne&author=UVA.%20Buddhika&pages=351-372&publication_year=2013)

Seneviratne G, Wijepala PC, Chandrasiri KPNK (2017) Developed biofilm-based microbial ameliorators for remediating degraded agroecosystems and the environment. In: Ahmad I, Husain FM (eds) Biofilms in plant and soil health. John Wiley & Sons Ltd., Chichester, pp 327–335
CrossRef (https://doi.org/10.1002/9781119246329.ch17)

Google Scholar (http://scholar.google.com/scholar_lookup?title=Developed%20biofilm-based%20microbial%20ameliorators%20for%20remediating%20degraded%20agroecosystems%20and%20the%20environment&author=G.%20Seneviratne&author=PC.%20Wijepala&author=KPNK.%20Chandrasiri&pages=327-335&publication_year=2017)

Sharma S (2012) Bioremediation: features, strategies and applications. Asian J Pharm Life Sci 2:202–213
Google Scholar (http://scholar.google.com/scholar_lookup?title=Bioremediation%3A%20features%2C%20strategies%20and%20applications&author=S.%20Sharma&journal=Asian%20J%20Pharm%20Life%20Sci&volume=2&pages=202-213&publication_year=2012)

Tang CY, Criddle QS, Fu CS, Leckie JO (2007) Effect of flux (transmembrane pressure) and membranes properties on fouling and rejection of reverse osmosis and nanofiltration membranes treating perfluoro-octane-sulfonate containing waste water. Environ Sci Technol 41:2008–2014
CrossRef (https://doi.org/10.1021/es062052f)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Effect%20of%20flux%20%28transmembrane%20pressure%29%20and%20membranes%20properties%20on%20fouling%20and%20rejection%20of%20reverse%20osmosis%20and%20nanofiltration%20membranes%20treating%20perfluoro-octane-sulfonate%20containing%20waste%20water&author=CY.%20Tang&author=QS.%20Criddle&author=CS.%20Fu&author=JO.%20Leckie&journal=Environ%20Sci%20Technol&volume=41&pages=2008-2014&publication_year=2007)

Tsiafouli MA, Thébault E, Sgardelis SP, De Ruiter PC, Van Der Putten WH, Birkhofer K, Hemerik L, De Vries FT, Bardgett RD, Brady MV, Bjornlund L (2014) Intensive agriculture reduces soil biodiversity across Europe. Glob Chang Biol 21:973–985
CrossRef (https://doi.org/10.1111/gcb.12752)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Intensive%20agriculture%20reduces%20soil%20biodiversity%20across%20Europe&author=MA.%20Tsiafouli&author=E.%20Th%C3%A9bault&author=SP.%20Sgardelis&author=PC.%20Ruiter&author=WH.%20Putten&author=K.%20Birkhofer&author=L.%20Hemerik&author=FT.%20Vries&author=RD.%20Bardgett&author=MV.%20Brady&author=L.%20Bjornlund&journal=Glob%20Chang%20Biol&volume=21&pages=973-985&publication_year=2014)

Vidali M (2001) Bioremediation: an overview. Pure Appl Chem 73:1163–1172
CrossRef (https://doi.org/10.1351/pac200173071163)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Bioremediation%3A%20an%20overview&author=M.%20Vidali&journal=Pure%20Appl%20Chem&volume=73&pages=1163-1172&publication_year=2001)

Weerarathne N, Seneviratne G (2013) Biofilmed biofertilizers induce drought tolerance of rice. In: Interdrought–IV conference, Perth, Australia
Google Scholar (https://scholar.google.com/scholar?q=Weerarathne%20N%2C%20Seneviratne%20G%20%282013%29%20Biofilmed%20biofertilizers%20induce%20drought%20tolerance%20of%20rice.%20In%3A%20Interdrought%E2%80%93IV%20conference%2C%20Perth%2C%20Australia)

Wei H, Liu W, Zhang J, Qin Z (2017) Effects of simulated acid rain on soil fauna community composition and their ecological niches. Environ Pollut 220:460–468
CrossRef (https://doi.org/10.1016/j.envpol.2016.09.088)

Google Scholar (http://scholar.google.com/scholar_lookup?title=Effects%20of%20simulated%20acid%20rain%20on%20soil%20fauna%20community%20composition%20and%20their%20ecological%20niches&author=H.%20Wei&author=W.%20Liu&author=J.%20Zhang&author=Z.%20Qin&journal=Environ%20Pollut&volume=220&pages=460-468&publication_year=2017)

Wittebolle L, Marzorati M, Clement L, Balloi A, Daffonchio D, Heylen K, De Vos P, Verstraete W, Boon N (2009) Initial community evenness favours functionality under selective stress. Nature 458:623–626
CrossRef (https://doi.org/10.1038/nature07840)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Initial%20community%20evenness%20favours%20functionality%20under%20selective%20stress&author=L.%20Wittebolle&author=M.%20Marzorati&author=L.%20Clement&author=A.%20Balloi&author=D.%20Daffonchio&author=K.%20Heylen&author=P.%20Vos&author=W.%20Verstraete&author=N.%20Boon&journal=Nature&volume=458&pages=623-626&publication_year=2009)

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