BKAP637
[1-8]

RESEARCH ARTICLE Bhartiya Krishi Anusandhan Patrika

eVkthukfeDl vkj bld midj.k vkj l,¶Vo;j

T;kfrdk HkkVh[1] jRuk çHkk[2] f}t'k pæ feJk[1]

lkjk'k

i"BHkwfe% li.k ç—fr e] l{ethok dk fofHkUu çdkj dh i;koj.kh; ifjfLFkfr;k e Qyr&Qyr ik;k tk ldrk gA ikjifjd rduhdk dk mi;kx djd vf/kdk'k leæh thou ;k rk vlL—r ;k lL—fr d fy, pukrhi.k gA

fof/k;k% ,d i;koj.k ueu l lh/k çkIr thukfed MVk d fo'y"k.k d ek/;e l] eVkthukfeDl lHkh l{ethok d v/;;u dk l{ke cukrk g] Hky gh mUg llL—r fd;k tk ldrk g ;k ughA ;g ektn çtkfr;k dh igpku d lkFk&lkFk mud çk—frd vkokl e ekbØkfc;y lenk;k dh dk;{kerk d ckj e Kku fudkyu dh vuefr nrk gA

ifj.kke% ;g y[k mi;kx fd, x, vR;k/kfud eVkthukfeDl –f"Vdk.k vkj mul tM l,¶Vo;l vkj VYl dk lkjk'k nrk gA vçkl; l{ethok dk le>u vkj mudk mi;kx dju d fy,] eVkthukfeDl ekbØkfc;y nfu;k dh fo'kky fofo/krk rd igp çnku djrk g vkj vdkfnfed lenk;k vkj vk|kfxd lfVXl nkuk e egRoi.k :i l mUur gvk gA

e[; 'kCn% eVkthukfeDl] eFkMl] l,¶Vo;l] VYlA

Metagenomics and Its Tools and Softwares

Jyotika Bhati[1], Ratna Prabha[2], Dwijesh Chandra Mishra[1]

10.18805/BKAP637

ABSTRACT

Background: Throughout all of nature, microorganisms can be found thriving in a variety of environmental circumstances. Most marine life is either unculturable or challenging to culture using conventional techniques.

Methods: Through the analysis of genomic data obtained directly from an environmental sample, metagenomics enables the study of all microorganisms, regardless of whether they can be cultured or not. This allows for the identification of the species present as well as the extraction of knowledge about the functionality of microbial communities in their natural habitat.

Result: This article summarizes the state-of-the-art metagenomic approaches used and their associated softwares and tools. In order to comprehend and utilise unculturable microorganisms, metagenomics provides access to the enormous diversity of the microbial world and has significantly advanced both academic communities and industrial settings.

Key words: Metagenomics, Methods, Softwares, Tools.

iLrkouk

eVkthukfeDl dk;kRed thu LØhfux ;k vuØe.k fo'y"k.k dk mi;kx djd ,d fo'k"k okrkoj.k l vyx fd, x, jkxk.kvk dk v/;;u gA eVkthukfeDl ij v/;;u jkxk.kvk dh fofo/krk] lenk;k dh ljpuk] vkuof'kd vkj fodkloknh lc/kk] dk;kRed xfrfof/k;k vkj i;koj.k d lkFk ckrphr vkj lc/kk ij /;ku dfær djrk gA eVkthukfeDl ,d 'kfä'kkyh midj.k d :i e mHkjk g ftldk mi;kx ekbØkfc;y lenk;k dk v/;;u dju d fy, fd;k tk ldrk g] Hky gh lnL; thok dh ikjifjd vyxko dk mi;kx djd ç;kx'kkyk e llL—r gku dh {kerk gkA blu i;koj.k e l{etho thou dh fofo/krk dk o.ku dju dk volj Hkh çnku fd;k g D;kfd db vHkh Hkh llL—r gku e vleFk g ¼Yasir *et al*., 2014½A eVkthukfeDl ,du;k –f"Vdk.k g tk fdlh fo'k"k okrkoj.k e l{ethok dh tkp d fy, dk;kRed thu LØhfux ;k vuØe.k

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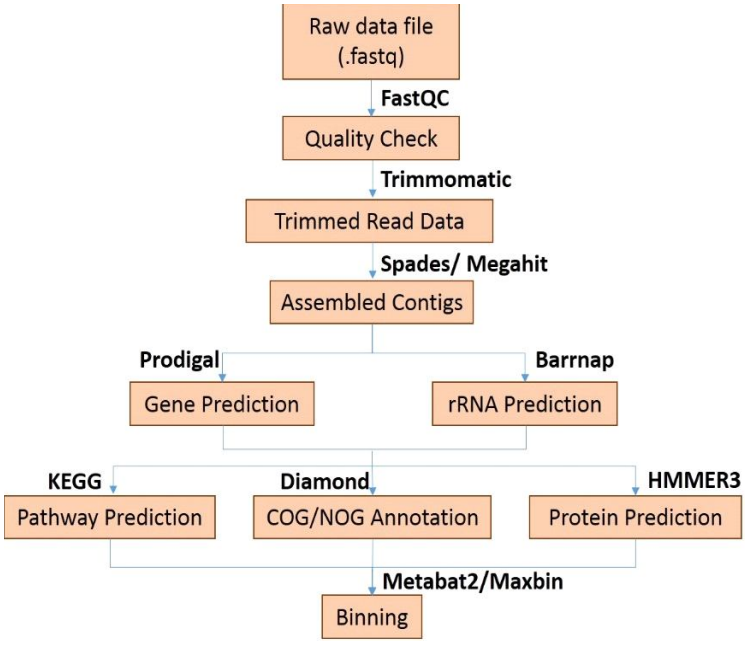
fo'y"k.k dk mi;kx djrk gA eVkthukfeDl] ftle ikuh ;k feêh tl xg d vf/kdk'k vkoklk e l{ethok d lxg l Mh,u, dk çR;{k fu"d"k.k vkj Dykfux 'kkfey g] dk i;koj.k vkj lkenkf;d thukfeDl d :i e Hkh tkuk tkrk gA i;koj.kh; thuke dk vyx fd;k tkrk g] [kfMr fd;k tkrk g] vkj fQj bld lykfLeM dk mi;kx djd ,d tho e Dyku fd;k tkrk g] ftle x.kk dju dh {kerk gkrh gA llL—r gku d ckn] thok dk mi;kx eVktukfeDl iLrdky;k d fuek.k d fy, fd;k tkrk g] ftudk Mh,u, vuØe.k ¼Nazir] 2016½ dk mi;kx djd fo'y"k.k fd;k tkrk gA

i;koj.k d ueuk l lh/k Mh,u, dh Dykfux dh vo/kkj.kk dk lcl igy 1986 e Pace vkj mud lg;kfx;k }kjk çLrkfor fd;k x;k Fkk ¼Pace *et al*-] 1986½] vkj Schmidt vkj mud lg;kfx;k u 1991 e ¼Schmidt *et al*-] 1991½ 16S rRNA thu vuØe v/;;u d fy, Qt oDVj e fidklykdVu l Mh,u, Dyku dju d fy, bl fof/k dk fu;kftr fd;kA 1995 e igy mRiknd dk;&lpkfyr eVkthukfeDl iLrdky;k dh tkp dh xb Fkh vkj mUg tykbcjht ¼Healy *et al*-] 1995½ d :i e tkuk tkrk FkkA gkykfd] tfycjh dk igyh ckj 1998 e mi;kx fd;k x;k Fkk vkj tk Handelsman vkj mudh Vhe ¼Handelsman *et al*-] 1998½ }kjk ^^l{ethok d ,d l;ktu l Mh,u, d çR;{k fu"d"k.k vkj Dykfux }kjk l{ethok d thukfed v/;;u^^ d :i e of.kr fd;k x;k FkkA urhtru] vf/kdk'k tho tk igy ikjifjd rjhdk l nxe Fk] vc miyC/k gA ekbØkfc;y nfu;k dl dk; djrh g] bldh 0;kid le> çkIr dju d vfre y{; d lkFk eVkthukfeDl lkenkf;d thuke dk lnfHkr djrk gA eVkthukfeDl ,d j.kuhfr –f"Vdk.k çnku djrk g tk rhu çkFkfed bVjfyDM Lrjk] ueuk çlLdj.k] Mh,u, vuØe.k vkj dk;kRed fo'y"k.k ¼Maria-Eugenia *et al*-] 2009½ ij vul/kku dk ,dh—r djrk gA i;koj.kh; ueuk e l{ethok dh dy l[;k dk 99% rd mudh fofo/krk fu/kkfjr dju d fy, bl rduhd dk mi;kx djd i<k tk ldrk g ¼Prayogo *et al*-] 2020½A lkenkf;d thukfeDl] i;koj.k thukfeDl] vkj tul[;k thukfeDl eVkthukfeDl ¼Neelakanta and Sultana] 2013½ d fy, vkx dh 'kCnkoyh gA

eVktukfeDl :ij[kk

fp= 1 eVkthukfeDl v/;;u efn'kk fn[kkrk gA i;koj.kh; ueuk ¼Jimenez *et al*-] 2012½ l miU;kl to&v.kvk dk fudkyu d fy, eVkthukfeDl dk nkj.kuhfr;k] dk;kRed vk/kkfjr vkj vuØe vk/kkfjr e foHkkftr fd;k x;k gA vuØe eVkthukfeDl dk v/;;u ekbØkfc;y lenk;k dh ljpuk l lcf/kr gA fdlh fn, x, lnHk e ,d lenk; cuku e tku oky fofHkUu rRok d chp lc/kk dk le>uk lkenkf;d ljpuk d v/;;u dk e[; y{; gA



fp= 1 eVktukfeDl dk;çokgA

ikfjfLFkfrdh vkj tfod çfØ;kvk d v/;;u d fy,] lenk; d lnL;k d chp lc/kk dk egRoi.k Kku gkrk gA vlcyh] fcfux] vkj ekbØkfc;y lenk; fo'y"k.k –f"Vdk.k tl VDlkukfked çkQkbfyx] thu Hkfo";ok.kh] vkj eVkc,fyd jkLr ekfyd ljpukRed eVkthukfeDl rduhd cukr g ¼Jimenez *et al*-] 2012; Alves *et al*-] 2018; Roumpeka *et al*-] 2017½A

dk;kRed eVkthukfeDl ,d fof'k"V çkVhu dk mRiknu dju oky thu d mi;kx d fy, lefir gA to çk|kfxdh {k= e mi;kx fd, tk ldu oky çk—frd inkFkk dh [kkt dk;kRed eVkthukfeDl d foKku d lkFk ,d ub pukrh i'k djrh gA thu fuek.k] LØhfux] vkj thu vfHk0;fä dN ekfyd rduhd g ftudk mi;kx dk;kRed eVkthukfeDl e miU;kl ,tkbek dk [kktu d fy, fd;k tkrk gA bu rduhdk dk vuØe] ih,Q,,e] ljpuk Hkfo";ok.kh] vkj Qkbyktufvd fo'y"k.k d lkFk&lkFk b"Vre ih,p nj] b"Vre rkieku nj vkj çkVhu xfrfof/k fo'y"k.k tl çkVhu mRikn y{k.k o.ku tl to lpukRed fo'y"k.k }kjk ikyu fd;k tk ldrk gA

ikfjfLFkfrdh vkj to çk|kfxdh tkp e ekbØkfc;y lenk;k dh tkp d fy, ,d fof/k d :i e] ljpukRed vkj dk;kRed eVkthukfeDl v/;;u e gkFk l dke djr gA nkuk ekbØkfc;y ikfjfLFkfrdh d lkFk pukfr;k dh uho d :i e dke djr g] vFkkr ^i;koj.k e fdl çdkj d l{e tho g\^ vkj ^; l{etho i;koj.k e D;k Hkfedk fuHkkr g\

to lpuk foKku midj.k vkj l,¶Vo;j ¼rkfydk 1½ eVkthukfeDl v/;;u e egRoi.k Hkfedk fuHkkr gA SqueezeMeta ¼Tamames and Puente-Sanchez] 2019½ vkj MG-RAST ¼Keegan *et al*-] 2016½ ,d i.k idt vk/kkfjr midj.k g tk x.koÙkk tkp l ydj vlcyh vkj thu dh igpku vkj ,ukV'ku rd lHkh fo'y"k.k djr gA to lpuk foKku midj.kk dk mi;kx vUo"k.k y{;k ij fuHkj djrk gA mnkgj.k d fy,] i;koj.k ueuk fo'y"k.k to lpuk foKku çk|kfxfd;k }kjk lgk;rk çkIr g] tlk fd 16S rRNA MVk ¼Niu *et al*-] 2018½ d fo'y"k.k e gA eVkthukfeDl –f"Vdk.k e mi;kx fd, tku oky to lpuk foKku fo'y"k.k d dN mnkgj.k fuEufyf[kr g%

vlcyh

vlcyh d fy, tku l igy] FastQC Vy d lkFk j, jhMl dh x.koÙkk dh tkp dh tkrh g vkj Trimmomatic l,¶Vo;j dk mi;kx djd jhMl dk fVe fd;k tkrk gA vçlL—r thok d thuke dk iuikIr dju d fy,] NkV fVe fd, x, i<u oky VdMk l ych thukfed lkexh dk iuh çkIr dju d fy, vlcyh vko';d gA yc vuØek dk contigs dgk tkrk gA eVkthuke vlcyh e mi;kx dh tku okyh nk lkekU; fof/k;k OLC vkj de Bruijn xkQ gA SequeezeMeta ¼Tamames and Puente-Sanchez] 2019½ tl dN l,¶Vo;j vuØfed] lg&vlcyh vkj gkbfcM vlcyh –f"Vdk.kk d vk/kkj ij fodflr fd, x, gA vU; fo/kkuHkk midj.k IDBA_UD ¼Peng *et al*-] 2012½] eVkekl ¼Treangen *et al*-] 2013½] exkfgV ¼Dinghua *et al*-] 2015½] eVkDokLV ¼Alla *et al*-] 2016½ vkj eVkoyoV ¼Namiki *et al*-] 2012½ gA

fcfux

fcfux Mh,u, vuØek dk legh—r dju dh çfØ;k g tk fudV lc/kh thok l ,dy thuke ;k thuke dk çfrfuf/kRo dj ldrk gA tfod VDlku dk çfrfuf/kRo dju d fy, dfVXl dk fcfux }kjk oxh—r fd;k tkrk gA fcfux fo'y"k.k d fy, mi;kx fd, tku oky l,¶Vo;j eVkokV ¼Strous *et al*-] 2012½ vkj d,ud,DV ¼Alneberg *et al*-] 2014½ gA eVkokV dh mPp lVhdrk g tcfd CONCOCT tfVy ekbØkfc;y lenk;k dkA

vuØe fo'y"k.k

ljy lj[k.k vkj ,dkf/kd lj[k.k dk mi;kx djd fofHkUu çdkj d thok d vuØek dh ryuk dju d fy, vuØe fo'y"k.k ¼sequence analysis½ dk mi;kx fd;k tkrk gA lcl vf/kd bLreky fd;k tku okyk Vy CykLV ¼cfld ykdy ,ykbueV lp Vy½ gA lj[k.k vi{kk eY; ¼b&eY;½ ¼Altschul *et al*-] 1990½ d vk/kkj ij lkf[;dh; :i l cuk, tkrk gA bld vykok vuØek dk fo'y"k.k VDlkukfked çkQkby] COGs ¼v,Fkky,xl thu d DyLVj½ vkj KEGG ikFko d fy, fd;k tkrk gA

çkVhu ifjokj dh igpku

ikfjokfjd Lrj ij çkVhu vuØek d chp lc/k n[ku d fy,] Pfam MVkcl dk mi;kx fd;k tkrk gA ;g çkVhu ifjokjk dh igpku dju d fy, fNi g, ekdko e,My dk mi;kx djrk g ¼Khandelwal *et al*-] 2017½A

çkVhu ljpuk io&lpuk

çkVhu dl dke djrk g ;g le>u d fy, çkVhu dh

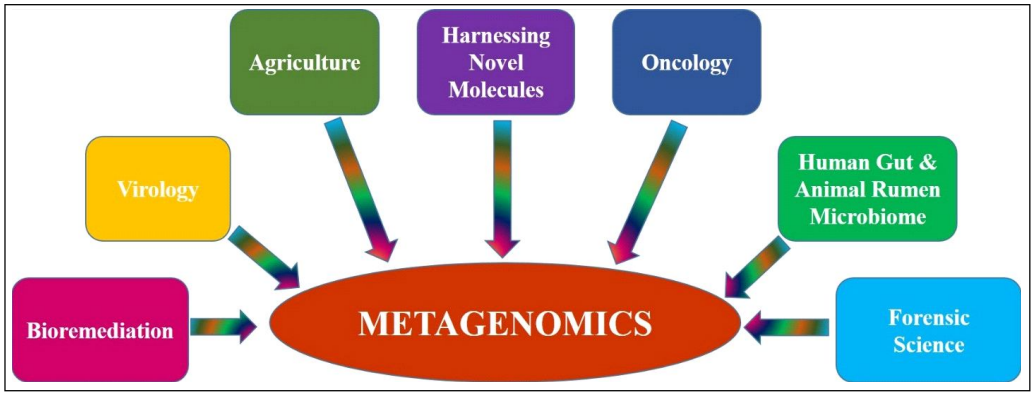
rkfydk 1% eVk tukfeDl midj.k vkj l,¶Vo;j mudh dk;{kerk d vulkj legh—rA

midj.k@l,¶Vo;j	fooj.k	lnHk
eVk tukfeDl vlcyh		
eVkoyoV	fyuDl/;fuDl dekM&ykbu Vy; cMh ek=k e RAM dh vko';drk gkrh g; pyu e db fnu yx ldr g	Namiki *et al*] 2012
eVkoyoV&,l,y	leku fo'k"krkvk d lkFk eVkoyoV dk foLrkj; dkbejk dk cgrj irk yxkuk	Afiahayati *et al*] 2014
vkbMhch,&;Mh	fyuDl/;fuDl dekM&ykbu Vy; cMh ek=k e RAM dh vko';drk gkrh g; pyu e db fnu yx ldr g	Peng *et al*] 2012
exkfgV	fyuDl/;fuDl dekM&ykbu Vy; de eekjh vkj çkllj vko';drk,] gkykfd doy dN fodYik d fy,	Dinghua *et al*] 2015
eVkekl	fyuDl/;fuDl dekM&ykbu Vy; db vU; l,¶Vo;j VYl ij fuHkj djrk g; mi;kx fd, x, vlcyj d vk/kkj ij cMh ek=k e RAM dh vko';drk gk ldrh g	Treangen *et al*] 2013
eVkDokLV	fyuDl/;fuDl dekM&ykbu Vy; mPp çn'ku	Alla *et al*] 2016
fcfux		
eVkcV	fyuDl/;fuDl dekM&ykbu; mfpr le; e lk/kkj.k dekfMVh/MLdV,i ihlh ij pyu d fy, fMtkbu fd;k x;k	Kang *et al*] 2015
eDlfcu	fyuDl/;fuDl dekM&ykbu; e,My cuku d fy, 50 thch je vkj 24 ?kV dh vko';drk gkrh g	Wu *et al*] 2014
eVkokV	th;vkb vk/kkfjr; MLdV,i gkMo;j ij pyu d fy, fMtkbu fd;k x;k	Strous *et al*] 2012
CONCOCT	fyuDl/;fuDl dekM&ykbu; vU; l,¶Vo;j ij fuHkj djrk g; 'k#vkr e vlcyh d fy, j eVk dk bLreky fd;k	https%//arxiv-org/abs/ 1312-4038
thu io&lpuk		
eVkthu ,ukVVj	fyuDl/;fuDl dekM&ykbu ;k oc bVjQl d ek/;e l miyC/k ¼10 ,ech rd lhfer oc bVjQl½	Hideki *et al*] 2008
v,Qfy;k	fyuDl/;fuDl dekM&ykbu ;k oc bVjQl d ek/;e l miyC/k ¼30 ,ech rd lhfer oc bVjQl½	Hoff *et al*] 2009
Ýxtuldu ¼FragGenScan½	Linux/Unix dekM&ykbu d :i e miyC/k; feuVk/?kVk e dekfMVh/MLdV,i gkMo;j ij pyu d fy, fMtkbu fd;k x;k	Ro *et al*] 2010
çkDdk	Linux/Unix dekM&ykbu d :i e miyC/k; vU; l,¶Vo;j ij fuHkj djrk g; lekukrj çlLdj.k dk mi;kx djrk g	Torsten] 2014
Mkeu MVkcl		
bVjçk	14 çkVhu/Mkeu/ikfjokfjd MVkcl dk l?k	https%//www-ebi-ac-uk/interpro/
bVjçkLdu	Linux/Unix dekM&ykbu d :i e miyC/k; ;k oc&bVjQl; ;k ,ihvkb d ek/;e l	Quevillon *et al*] 2005
ikFko MVkcl		
dbthth ¼KEGG½	çfrfØ;kvk/ikFkk d fy, v,uykbu llk/ku; 'kYd d fy, Mkmuyk dju d fy, miyC/k MVk; oc bVjQl ;k ,ihvkb d ek/;e l igpk tk ldrk g	Ogata *et al*] 1999

Table 1: Continue.....

Table 1: Continue.....

eVk lkbd	çfrfØ;kvk/ikFkk d fy, v,uykbu l lk/ku; MkmuykM dju d fy, miyC/k MVk; oc bVjQl ;k ,ihvkb d ek/;e l igpk tk ldrk g	Caspi *et al*-] 2020
fo'y"k.k ikbiykbu		
,eth&jLV	xkfQdy ;tj bVjQl d lkFk v,uykbu ç.kkyh	Keegan *et al*-] 2016
bchvkb eVk tukfeDl	xkfQdy ;tj bVjQl d lkFk v,uykbu flLVe; EBI ENA e MVk gkuk vko';d g	Hunter *et al*-] 2014
vkb,eth/,e	xkfQdy ;tj bVjQl d lkFk v,uykbu flLVe	Markowitz *et al*-] 2014
LDoh teVk	fyuDl/;fuDl dekM&ykbu Vy; cMh ek=k e RAM dh vko';drk gkrh g; pyu e db fnu yx ldr g	Tamames and Puente-Sánchez] 2019
flYok	th;vkb vk/kkfjr; MLdV,i gkMo;j ij pyu d fy, fMtkbu fd;k x;k	Pruesse *et al*-] 2007
exu	th;vkb vk/kkfjr; MLdV,i gkMo;j ij pyu d fy, fMtkbu fd;k x;k	Huson *et al*-] 2013



fp= 2% fofHkUu oKkfud {k=k e eVk tukfeDl d vuç;kxA

ljpuk dk le>uk vko';d gA çkVhu dh çkFkfed ljpuk bl ,UdkM dju oky thu d vuØe l vkrh gA çkVhu ljpuk dk to lpuk foKku dk iokueku v/;;u çkVhu d Hkkfrd x.kk vkj dk;k dk le>u e lgk;rk dj ldrk g ¼Raza] 2012½A

o'kkoyh fo'y"k.k

çkVhu v.kvk d legk d chp fodkloknh lc/kk dk fQj l cuku vkj ,d v.k d dN x.kk dh io&lpuk d fy,] Qkbyk tufVd fo'y"k.k fd;k tkrk g ¼Mehmood *et al*-] 2014½A Qkbyk tufVd fo'y"k.k e 0;kid :i l mi;kx fd, tku oky midj.k MEGA ¼Molecular Evolutionary Genetics Analysis½ ¼Tamura *et al*-] 2011½ vkj PHYLIP ¼Felsenstein] 1989½ gA

l{etho v/;;uk d vulkj] eVk thukfeDl dk cDVhfj;y eVk thukfeDl] Qxy eVk thukfeDl vkj ok;jy eVk thukfeDl e oxh—r fd;k tk ldrk gA oreku eVk thukfed vul/kku e] thok.k eVk thukfeDl d lkFk&lkFk vuØe fo'y"k.k eVk thukfeDl rth l c< jgk gA

vuç;kx

fpfdRlk] —f"k] i;koj.k lj{k.k] vkj vU; {k=k ¼fp= 2½ lfgr Mkeu e eVk thukfeDl vul/kku rth l vkx c< jgk gA l{etho k vkj ekbØkfc;y eVkckykbVl l miU;kl ck;k,fDVo ;kfxdk vkj dk;kRed thu dh igpku dju d fy, dk;kRed eVk thukfeDl egRoi.k gA eVk thukfeDl rduhd e ck;kdVfyLV thu ¼Uchiyama *et al*-] 2005½] i,ydVkbM flFkt dkfMx thu ¼Ginolhac *et al*-] 2004½]

,Vhck;kfVd çfrjk/k thu ¼,vkjth½ ¼Riesenfeld *et al*-] 2004½ lfgr db u, thu ik, x, gA

vuØe eVkthukfeDl vçlL—r l{ethok dk v/;;u dju e lgk;d gA ekbØkfc;y lenk; dh fofo/krk dh tkp djd] l{ethok dh çtkfr;k] vkuof'kdh vkj fodklokn bfrgkl d ckje lh[kuk lHko gA u, jkxtud ekbØkfc;y lk{; ¼Kasper *et al*-] 2020½ }kjk fpfdRlk lØe.kk d ektnk funku e l/kkj fd;k tk ldrk gA lL—fr dh fLFkfr dh vko';drk d fcuk] dk;kRed eVkthukfeDl LØhfux d ek/;e l y{; thu ;k lfØ; mRiknk rd igp ldr gA ektnk ,tkbe ifjokjk ;k ,tkbek d miU;kl lnL;k dh [kkt e dk;kRed eVkthuke lgk;rk tk doy fo'k"k Hkkfrd&jklk;fud ifjfLFkfr;k e lfØ; g] tk nkuk vk|kfxd vuç;kxk d fy, vf/kd mi;kxh g ¼Bekele *et al*-] 2021½A i;koj.k cDVhfj;k ¼Zhang *et al*-] 2021½ d dkcu] ukbVktu vkj lYQj pØ p;kip; dk fo'y"k.k dju d fy, eVkc,fydfeDl vkj dk;kRed eVkthukfeDl dk ;fXer fd;k x;k FkkA

feêh] xgj egkl kxjk] fgeunk] xïk vkj vU; vkokl k e jkxk.kvk dk v/;;u i;koj.kh; eVkthukfeDl dk ,d vuç;kx gA xLVkbVLVkbuy VDV e gkfudkjd cDVhfj;k dh [kkt] jä çokg lØe.k] QQMk e lØe.k] dæh; rf=dk r= lØe.k] vkj vU; chekfj;k fpfdRlk {k= d eVkthukfeDl d db mi;kxk e l dN gA ,Vhck;kfVd&çfrjk/kh cDVhfj;k ¼ARB½] ,Vhck;kfVd&çfrjk/kh thu ¼Nnadozie and Odume] 2019½] to&mRçjd] vkj nok, eVkthukfeDl vul/kku ¼Duarte *et al*-] 2020½ dk oreku Qkdl gA

vgen vkj mudh Vhe ¼2018½ }kjk ,d v/;;u fd;k x;k Fkk] ftle [kkj feêh d ekbØkck;ke dh ey ljpuk vkj v,Lek,MkIV'ku e 'kkfey miU;kl vkuof'kd rRok dh [kkt dh xb FkhA 16S rRNA thu vuØe fo'y"k.k u çkVhukcDVhfj;k ¼Proteobacteria½] ,fDVukcDVhfj;k ¼Actinobacteria½] tefVekuMVl ¼Gemmatimonadetes½] cDVj,bMVl ¼Bacteroidetes½] QfeD;Vl ¼Firmicutes½ vkj ,flMkcDVhfj;k ¼Acidobacteria½ l lcf/kr gykfQfyd/gykVkyjV Qkbyk Vkbll d çHkRo dk ldr fn;k gA bl dk;kRed eVkxu,feDl –f'Vdk.k u v,LekVkyjV ¼Osmotolerant½ Dyku SSR1, SSR4, SSR6, SSR2 dk BCAA_ABCtp, GSDH, STK_Pknb] vkj duf3445 thuk dh igpku dhA mijkä jkxk.kvk d Hkhrj çpfyr vkuof'kd rRok d fMdkfMx dk mi;kx ;k rk feêh dk l/kkju d fy, fd;k tk ldrk g ;k mud vkuof'kd :i l l'kkf/kr :i Qlyk dk [kkj okrkoj.k e çfrjk/k vkj thfor jgu e lgk;rk dj ldr g ¼Ahmed *et al*-] 2018½A

—f"k] tho foKku] çn"k.k dh jkdFkke] Åtk] i;koj.k] okrkoj.k vkj vU; {k=k ij vul/kku eVkthukfeDl ¼Suttner *et al*-] 2020½ dk mi;kx djrk gA vR;f/kd vkokl] leæ vkj Hkfe lHkh e jkxk.kvk d v/;;u dh {kerk gA cMh l[;k e l{etho feêh e jgr g] vkj eVkthukfeDl 'kk/k l irk pyk g fd ble ,Vhck;kfVDl vkj ,VhQxy inkFkk ¼Gillespie *et al*-] 2002½ dk [ktkuk gk ldrk gA

fu"d"k

ekbØkfc;y lenk;k l lcf/kr ç'uk vkj fofHkUu okrkoj.kk e mudh Hkfedk dk lckf/kr dju d fy, eVkthukfeDl cgr rt xfr l mHkj jgk gA eVkthukfeDl dh fo'kky lHkkfor Hkfedk d dkj.k] ifj.kkeh MVklV dk i.k mi;kx dju d fy, eVkthukfeDl dk ,d fo'o0;kih igy cuku dh vko';drk g tkfnfu;k Hkj e lHkh çdkj dh eVkthukfed ifj;ktukvk dk ,d lkFk yk,xhA fudV Hkfo"; e] vU; ^vkfeDl^ fof/k;k tl fd eVkVufLØlVkfeDl vkj eVkçkVkfeDl d lkFk ,dhdj.k djd] eVkthukfed gekj i;koj.k dk n[ku d egRoi.k ?kVdk e l ,d gkxkA lL—r milePp; dh ijokg fd, fcuk eVktukfeDl cMh ek=k e vkuof'kd tkudkjh dk ykHk mBk ldrk g vkj fofo/k vçdkf'kr ekbØkfc;y lenk;k d vkuof'kd fodkl e Kku dh deh dk Hkh gy dj ldrk gA dk;kRed eVkthukfeDl LØhfux rduhd ,d etcr vul/kku midj.k g ftle to&mRçjd dh {kerk g tk i;koj.k vkj 0;kolkf;d :i l egRoi.k gA

lnHk

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