c. Statement of research achievements, if any, on which any award has already been received by the applicant. Please also upload brief citation(s) on the research work(s) for which the applicant has already received the award(s) (not to exceed 2000 words)

Following some research activities in last few years which were recognised I the for form of several recognitions and awards:

- Dr Khan's lab is actively engaged in designing new inhibitors against NDM-1 and CTX-M "superbug" using virtual screening, molecular docking and simulation modeling. These enzymes (resistant markers) have been cloned and expressed for kinetics and structural studied in order to map the target site of newly identified lead molecules. A good number of inhibitor molecules have been so far screened and tested against these purified enzymes. Some of the inhibitors have already proved to be potential drug candidates against multi-drug resistant bacteria. This is truly an original contribution to the medical/biological science since not much antibiotics are left to treat infection caused by NDM-1 producing bacteria (***PLoS ONE***, 2013,; ***J Biomol Structure and Dynamics***, 2014; ***European Journal of Medicinal Chemistry*** , 2013, ***Sci Report, 2017, Phys Chem Chem Phys., 2019, ACS Omega, 2020***).

- ***Moreover,*** he has investigated the significance of non-active site residues involved in the structure and function of NDM-1 using cloning and site-directed mutagenesis strategy to further understand the insight of mechanism. A complete structural functional map has been developed to design lead molecules as future therapeutics. (***Antimicrobial Agent and Chemotherapy,*** 2015, ***FEMS Micrbiol Lett, 2019, PCCP-RSC , 2019, IJBM, 2018***).

- A novel variant, **NDM-4** was discovered by his group as a first report from India (***J Med Microbiol.*** 2014, which was a **new drug-resistance mechanism.** This research has brought changes in the health policies of our country to adopt infection control measures to save lives of millions of poor patients. This research has raised issues in parliament after the wide coverage by National and International print and electronic media.

- He has extensively explored mechanisms of antibiotic resistance in bacteria with specific reference to beta-lactamases. New resistant markers on plasmids were characterized in his lab and also detected novel variants of NDM-1. He has first time reported NDM-4 from Indian hospital environment. Moreover, he has also shown that these resistant markers are mobile and accessible to susceptible strains of bacteria through Horizontal Gene Transfer. (***J. Med. Microbiology*** , 2010, ***Journal of Chemotherapy*** , 2011, ***J Med Microbiology***, 2012, ***Front. Microbiol***. 2016, ***International J Antimicrobial Agents***, (2017, 2018, 2019). Recently as **novel mechanism** has been explored by his group as role of LysM domain protein in carbapenemase resistance (***IJBM,*** 2020). He has first reported NDM-4 producing *Citrobacter freundii*, co-associated with $bla_{\text{OXA-9,}}$ $bla_{\text{SHV-1}}$ and $bla_{\text{CMY-149}}$ as well as *Citrobacter braakii, Klebsiella oxytoca* and *Enterobacter cloacae* were identified in association with $bla_{\text{OXA-1}}$ and $bla_{\text{CMY-145}}$, $bla_{\text{OXA-1}}$ and $bla_{\text{OXA-9}}$ and, $bla_{\text{OXA-1,}}$ $bla_{\text{OXA-9}}$ and $bla_{\text{CMY-149,}}$ respectively. NDM-4 producing *Klebsiella pnemoniae* with incompatibility group

IncP was first identified (***Front Microbiol*. 2018; *Int J Antimicrob Agents* 2017,2018).** *bla*$_{NDM-4}$, *bla*$_{NDM-5}$ and *bla*$_{NDM-7}$ in *E. arogenes* were first time detected in NICU of tertiary care hospital in India. ***Microb. Drug Resist*. 2018).**

He had described a novel ***ST3344 as new Sequence types*** in two NDM-1 producing *K. pneumoniae* isolates from neonates admitted in NICU of one of the North Indian Hospitals. Moreover, these strains were also found to carry *bla*$_{CTX-M-15}$, *bla*$_{CMY-1}$ and *bla*$_{SHV-1.}$ ***Int J Antimicrob Agents.* 2019).**

His research group has also discovered several virulent factors and IS/Tn genetic mobile elements involve in resistant marker transfer using whole genome sequencing through NGS. Sequence analysis also identified several new MLST, depicting occurrence of novel bacterial strains in the community and hospital settings (***Genome Announce (ASM),*** 2017; ***Gut pathogen*** 2018, ***Int J Antimicrob Agents*** 2019; ***J Global Antmicrob Res.,*** 2020)

- His group has also elucidated mode of action of natural and synthetic molecules including, several Nano-composite preparations against infections in general and dental caries in particular which is a predominant cause of tooth decay and endocardiatis, a serious heart problem (***PloS ONE*** , 2013, ***Phytomedicine***, **2012, *Journal of Antimicrobial Chemotherapy*** 2008; ***J Applied Microbiol,*** 2009, ***Molecules,*** 2009).
- He has developed a novel approach to control topical microbial infections through nanoparticles induced Photodynamic therapy. During this study infections were induced in animal models which were than treated successfully using photodynamic therapy. (***Biofouling,*** 2016; ***Appl Microbiol Biotechnol,*** 2016 ***International J Nanomedicine***, 2012, ***J Photochem Photobiol*** B, 2017, 2018; ***Future Microbiol,*** 2018; ***Photodiag. Photodyn Ther,*** 2017, 2019,2019[a] ; ***BBRC,*** 2019).
- A novel approach of **CRISPRi-dCAS9** system has been established to knock down biofilm and quorum sensing genes to inhibit the formation of biofilm. Hence technology may be proposed as a therapeutic approach **(*Fron Cell Inf Microbiol*, 2017, *Front Immunol,* 2017)**
- A proteomic approach has also been introduced to understand associated proteins involved in facilitating drug resistance in bacteria along with the existing antibiotic resistant markers. Moreover role of biofilm in resistance has also been explored through different pathways being identified using proteomic approaches (***Biochem. Biophys. Res. Commun***, 2016, 2016[a] ; ***J Glob Antimicrob Resist.*** 2017; ***Microb Pathog. 2019, J Proteomics, 2019, Microbial Pathogen****., 2019, 2020).*
- His novel combination-therapy against Extended-spectrum beta-lactamase and metallo beta-lactamase producing bacterial infections has been very well received (***Future Microbiol*** , 2013,2019). Moreover, a novel mechanism of synergy was also described first time in his lab (***Frontier Microbial***, 2016, ***Front Pharmacol. 2017, IJBM, 2018; J Mol Recog., 2018; Eur. J. Med Res., 2020;***).

- He has also demonstrated role of drugs on Basal Transcription Machinery with special reference to anti-cancer drugs. With this, he raised a question whether anticancer drugs interact transcriptional machinery via interfering with histone modulation (***PloS ONE***, 2012, ***Cell Biochem. Biophs.*** (2011) ; ***European Journal of Pharmaceutical Sciences,*** **2008)**

Significant Technologies developed:

- ❖ He has developed several technologies to control infections caused by multi drug resistant bacteria using Photo-dynamic therapy and Nano-biotechnology (***Photochem Photobiol-B,*** 2017, 2019; ***Photodiagnosis Photodyn Ther,*** 2019, 2019[a]).
- ❖ CRISPRi, a gene editing technology was developed to inhibit biofilm mediated infections, by targeting several quorum sensing and biofilm forming genes. This could has been used as to engineer probiotic bacterial strain to treat gut infections as one of he major reservoir of antibiotic resistant strains in the human microbiome (***Front Immunology***, 2017; ***Front Cell Inf. Microbiology*** 2017; ***J Biomedical Res.,*** 2020.

Significant discoveries:

- ❖ First Discovery of NDM-1 in India from AU Khan's Lab. ***(JMM, 2014).***
- ❖ First reported NDM-4 producing *Citrobacter freundii*, (AK-82) co-associated with $bla_{\text{OXA-9}}$, $bla_{\text{SHV-1}}$ and $bla_{\text{CMY-149}}$ by his group.
- ❖ First time identified NDM-4 producing *Citrobacter braakii* (AK-84), *Klebsiella oxytoca* (AK-100) and *Enterobacter cloacae* (AK-108) were identified in association with $bla_{\text{OXA-1}}$ and $bla_{\text{CMY-145}}$, $bla_{\text{OXA-1}}$ and $bla_{\text{OXA-9}}$ and, $bla_{\text{OXA-1}}$, $bla_{\text{OXA-9}}$ and $bla_{\text{CMY-149}}$, respectively
- ❖ He has first time identified three NDM-4 producing *Klebsiella pnemoniae* with incompatibility group IncP in AK-97, AK-101 and AK-104 strains.
- ❖ His study revealed outbreak of multiple variants of bla_{NDM} (9; $bla_{\text{NDM-1}}$, 16; $bla_{\text{NDM-4}}$, 17; $bla_{\text{NDM-5}}$, and 2; $bla_{\text{NDM-7}}$) in clinically important bacteria (20 *Escherichia coli,* 18 *Klebsiella pneumoniae,* 02 *Citrobacter freundii,* 01 *Citrobacter braakii,* 01 *Klebsiella oxytoca,* 01 *Enterobacter cloacae,* 01 *Enterobacter aerogenes*. **(*Front Microbiol*. 2018, *Microb Drug Res.,* 2019)**
- ❖ First reported New Delhi Metallo-β-lactamase-1 producing *Cedecea lepagei*. **(*Int J Antimicrob Agents*. 2017)**
- ❖ This is the first report of $bla_{\text{NDM-4}}$, $bla_{\text{NDM-5}}$ and $bla_{\text{NDM-7}}$ in *E. aerogenes* species, isolated from the NICU of tertiary care hospital in India from his lab. **(*Microb Drug Resist*. 2018).**

- He described the first time a novel ST3344 in two NDM-1 producing *K. pneumoniae* isolates from neonates admitted in NICU of one of the North Indian Hospitals. Moreover, these strains were also found to carry *bla*$_{\text{CTX-M-15}}$, *bla*$_{\text{CMY-1}}$ and *bla*$_{\text{SHV-1.}}$
- He was first time identified the co-producing strains of NDM and OXA-48 exhibited high MICs value of carbapenems.
- His study explored varying replicon types (IncFIA, IncFIB, IncFIIAs, IncFIC, IncA/C, IncF, IncK, IncX, IncW and IncY), in these NDM-producing *K. pneumoniae* strain. **(*Int J Antimicrob Agents.* 2017, 2018).**

Co-existence of *bla*$_{\text{NDM-1}}$ and *bla*$_{\text{VIM-1}}$ producing *Moellerella wisconsensis* in NICU of North Indian Hospital: a first report from his lab **(*J Infect Dev Ctries,* 2020)**

Recognitions and Awards :

- Recipient of **Visitor's Award 2019.**
- Recipient of **Om Prakash Bhasin award 2019**
- **National Bioscience Award of DBT, Government of India , 2012**
- **Prof Asad U Khan** of Biotechnology, Appointed as **Adjunct Professor** in University of Catolica San Antonio de Murcia (UCAM) **Spain** for the period of two years.
- **Appointed as *Visiting Professor* in University Malaysia Terengganu, Malaysia for the period of two years w.e.f May 15, 2019.**
- Appointed as **Panel Expert** "Natural Science" of National Council for Promotion of Urdu Language, MHRD, Government of India, (2019-0nward)
- Recipient of Wockhardt Excellence Award of Jamia Hamdard 2018 (Silver plaque and 3 lakh rupees cash).
- Invited as Team member in **Joint Research Centre of the European Commission** for Survey on Antimicrobial Resistance (2018-onward).
- Invited by **International Health Management Association, Inc** (IHMA, USA) for Global Antimicrobial surveillance network.(January 2019- December 2019).
- Appointed as **Brand Ambassador** Bentham Scinece Publishers 2018-onward.
- Acted as Editor grant proposals for the National Science Centre, Poland
- **Prof Asad U Khan** of Biotechnology , Recognized as **eminent researcher** in the field of Antimicrobial Resistance by Government of India and research Council UK as per the prepared "Scoping Report on Antimicrobial Resistance" in India which was released on November 2017 during Newton's Award function in New Delhi. A total of 630 Institutions of the country have been incorporated in this study. Top 10 institutions were identified to be involved in active research on antimicrobial resistance. ***Aligarh Muslim University*** was placed number 4 in the area of antibiotic resistance research in the country. Report has also recognized **Prof Asad U Khan's** contribution in **Understanding molecular mechanisms of**

resistance, development of novel agents, diagnostics as eminent researchers, working in the country (page no. 60 on the published document of government of India).

- **Prof Asad U Khan** of Biotechnology, appointed as **expert member** of steering committee of ***UK Academy of Medical Sciences and Hamied Foundation UK-India AMR Programme***