农业资源研究中心 研究人员 岗位应聘申请表

<table>
<tr><td>姓 名</td><td>柏兆海</td><td>性 别</td><td>男</td><td>党 派</td><td>群众</td><td rowspan="5"></td></tr>
<tr><td>出生日期</td><td>1986.01.29</td><td>参加工作时间</td><td colspan="3"></td></tr>
<tr><td rowspan="2">毕业院校</td><td rowspan="2">中国农业大学资环学院</td><td>毕业时间</td><td colspan="3">2015 年 06 月</td></tr>
<tr><td>出站时间</td><td colspan="3">年 月</td></tr>
<tr><td>学 历</td><td>本科生学历</td><td>学 位</td><td>博士研究生</td><td>所学专业</td><td>植物营养</td></tr>
<tr><td>现工作/博士后单位</td><td colspan="6">中国农业大学资源与环境学院</td></tr>
<tr><td>现职务/职称</td><td>博士研究生</td><td>任职时间</td><td colspan="4">2011 年 09 月-2015 年 06 月</td></tr>
<tr><td>外语语种和水平</td><td colspan="2">英语 六级</td><td colspan="2">与本所有无亲属关系</td><td colspan="2">无</td></tr>
<tr><td rowspan="2">配偶情况</td><td>姓 名</td><td>郭伟杰</td><td>工作地点</td><td colspan="3">暂无</td></tr>
<tr><td>工作性质</td><td>暂无</td><td>户口所在地</td><td colspan="3">北京市通州区人才市场</td></tr>
<tr><td>E-mail</td><td colspan="2">baizh1986@126.com</td><td>联系电话</td><td colspan="3">13401023742</td></tr>
<tr><td rowspan="2">户口所在地</td><td colspan="3">正式户口所在地</td><td colspan="3">江苏省大丰市新丰镇五丰村</td></tr>
<tr><td colspan="3">非正式户口所在地（学生或博士后）</td><td colspan="3">北京市海淀区圆明园西路 2 号中国农业大学西校区</td></tr>
<tr><td>应聘岗位</td><td colspan="6">“食物-环境-资源”耦合与调控机制研究小组研究人员</td></tr>
</table>

一、学习进修经历（大学填起，研究生阶段注明指导教师）

- **2011 年 09 月-至今** 中国农业大学资源与环境学院，植物营养专业，硕转博，导师：陈清，张福锁教授；
- **2009 年 09 月-2011 年 06 月** 中国农业大学资源与环境学院，植物营养专业，硕士，导师：陈清，张福锁教授，李海港副教授；
- **2004 年 09 月-2008 年 06 月** 中国农业大学资源与环境学院，资源环境科学专业，本科，导师：陈清教授。

二、工作经历（含工作时间、单位名称及任职情况等）

- **2011 年 11 月-2014 年 12 月** 荷兰瓦赫宁根大学，土壤质量组，访问学者，合作导师：Oene Oenema；
- **2008 年 06 月-2009 年 09 月** 中国农业大学资源与环境学院，植物营养系，研究助理。

三、**代表性研究工作或学位论文工作介绍**（含参加/承担项目、研究基础、取得成果等）

博士期间主要工作是建立了建立了 NUFER-animal model，可用于分析我国不同畜禽种类和养殖体系在饲料生产-圈舍管理-粪尿储藏-粪尿加工-粪尿施用-动物食品消费整个环节的养分流动特征。硕士期间主要工作是基于土壤全磷和 Olsen-P 效应曲线，Olsen-P 和作物产量效应曲线以及 Olsen-P 和 $CaCl_2$-P 效应曲线，发展了我国土壤磷素管理模型。目前以第一作者发表 SCI 文章 3 篇（2 篇中科院 1 区文章，3 篇文章累积影响因子 11.6），中文核心文章 1 篇；以合作作者发表 SCI 文章 1 篇（中科院 1 区文章，影响因子 7.1）；以第一作者发表 3 篇英文国际会议论文集；参与多部书稿和科技手册编写。

- **代表性工作一：我国畜禽养殖的资源和环境代价，以及养分流动特征**

建立了 NUFER-animal model，可用于分析主要动物养殖类型（猪，蛋鸡，肉鸡，奶牛，肉牛及役用牛，山羊及绵羊）在饲料生产-圈舍管理-粪尿储藏-粪尿加工-粪尿施用-动物食品消费整个环节的养分流动特征。该模型区分不同动物类型的养殖体系之间的差异（后院养殖、传统养殖、养殖小区、放牧养殖以及规模化养殖）。同时模型输入模块区分了不同动物不同养殖阶段的饲料采食和养分摄入差异，因此可更准确的分析不同动物养殖体系的养分流动。同时 NUFER-animal model 建立了饲料采食量预测子模块和饲料分配子模块，将不同饲料分配到不同动物和养殖体系中，可实现分析不同动物产品资源需求的目的。该模型利用物质平衡法计算不同动物的养分排泄量，其准确度要高于常用的经典排泄系数法。此外，模型建立在区域尺度数据上，可实现分析畜牧业区域分布对我国资源利用和养分损失影响的目的。也可通过历史数据变化分析我国畜牧业生产体系变化对资源和环境的压力。该模型也可用于情景设计，如分析未来畜牧业养殖规模扩大和养殖体系变化对饲料需求、耕地需求和环境保护的影响。其结果已发表在 Environmental Science & Technology（1 区，5.87）和 Journal of Environment Quality（3 区，2.60）。研究成果分为 4 个部分：

1. **我国奶牛养殖体系养分流动特征**：通过 IPCC 报告和大量奶牛养殖文献，创造性的建立了奶牛饲料预测模型；并根据统计数据和文献结果，区分了我国奶牛 4 种主要养殖体系——传统养殖（1-9 头），放牧养殖（牧区），养殖小区（10-199 头）和规模化养殖场（>200 头）。这几种养殖体系在饲喂模式和粪尿处理方式之间存在显著差异。随后与 NUFER 模型结合，建立了 NUFER-animal 模型的奶牛养殖模块。分析表明，2010 年我国奶牛养殖总的氮磷投入量分别为 1987 和 346 千吨，其中仅有 188 千吨氮和 31 千吨磷进入牛奶，其余部分则损失到环境或累积在土壤中。在奶牛整个群体上，氮磷利用效率分别为 24%和 25%，远低于欧美等发达国家。而且不同养殖体系的养分利用效率存在显著差异。每生产 1kg 牛奶，集约化养殖体系虽然消耗较少量饲料，但是更依赖于高质量饲料，如牧草、玉米和大豆，因此集约化养殖体系需要更多的耕地资源，同时集约化养殖体系的粪尿还田利用低。未来规模化奶牛养殖场的增加一方面可以降低料奶比和提高奶牛群体尺度的养分利用效

率，另一方面会加大对耕地的需求以及促进氮磷环境排放增加。其结果发表在 Journal of Environment Quality（3 区，影响因子 2.60）。

2. **我国生猪养殖体的历史变化及对养分利用影响：**在奶牛工作基础上，继续开发了 NUFER-animal 生猪养殖模块。此外对生猪养分流动模块进行了拓展，将物质流动分析延伸到猪肉加工和消费环节，建立了 31 个省市区的生猪养殖流动账户，并分析了 1960 年到 2010 年的历史变化以及 2030 年生猪养殖情景分析。同时分析了养分利用效率和养分环境排放的历史变化。结果表明，1960 到 2010 年期间，我国生猪养殖从以家庭后院式养殖方式快速向集约化养殖方式转变。群体尺度上氮素利用效率从 18% 增加到 28%。然而氮素利用效率在系统尺度上却快速下降，从 1960 年的 46%降低到 2010 年的 11%，主要因素是生猪养殖向集约化养殖方式转变，而集约化养殖更依赖外源饲料投入且没有足够耕地施用生猪养殖所产生的粪尿。2010 年，总的氮素和磷素损失量达到 5289 和 829 千吨，分别是 1960 年的 30 倍和 95 倍。情景分析的结果表明，2030 年总的氮磷养分损失较 2010 年将分别增加 25%和 55%。通过对不同生产优化技术以及管理方式的情景分析表明，2030 年我国生猪养殖的总氮磷损失可分别降低 64%和 95%。虽然氮磷的减排潜力较大，但是这些措施的实施需要改变我国目前的生猪养殖方式，主要在包括粪尿管理，生猪种群管理以及饲养管理等方面。结果发表在 Environmental Science & Technology（1 区，影响因子 5.87）；

3. **我国畜禽养殖体系资源和环境代价系统分析：**在之前工作基础上，继续完成了 NUFER-animal 的蛋鸡、肉鸡、肉牛及役用牛，山羊和绵羊的模型。建立我国主要畜禽养殖类型的养分流动账户，目前模型可实现 1980，1990，2000 和 2010 的历史变化分析，并且根据 FAO 报告，设置了 2030 年和 2050 年的情景分析。目前分析结果表明，我国畜牧业养殖体系转变加剧资源短缺，如饲料粮和耕地。畜牧业区域分布不均匀，导致了区域内的资源短缺，并且限制了粪尿还田潜力，加剧了氮磷养分环境损失。到 2050 年，我国可能没有足够的饲料粮和牧草养活我们的畜牧业，且没有足够的耕地资源消纳产生的粪尿。因此未来，草地将成为改变我国畜牧业养殖的关键，因为其可以提供大量牧草资源以及足够的土地还田利用有机肥。目前文章初稿正在修改中，计划投高影响因子期刊。

4. **国外畜牧业先进养殖经验总结：**通过对欧美养殖体系的养殖技术和减排技术文献的阅读，系统的总结了整个食物链的养分减排技术，已完成 8.3 万字总结，计划以书稿形式发表。参观和访问了数个奶牛养殖场和粪尿处理厂，系统总结了荷兰奶牛养殖模式和粪尿处理技术。这些总结和对荷兰畜牧业的认识有利于在国内开展畜牧业方面的工作。

➢ **代表性研究工作二：我国土壤磷素管理研究。**

建立了土壤全磷和 Olsen-P 效应曲线，根据对全国长期定位试验数据的分析建立了钙质、酸性和中性土壤的土壤磷素和作物产量效应曲线和土壤 Olsen-P 和 $CaCl_2$-P 效应曲线，基于此发展了我国土壤磷素管理模型。硕士期间在全国青年土壤学家大会做报告 1 次；以第一作者发表中文核心和 SCI 文章各 1 篇，国际会议英文摘要 2 篇；合作作者发表 SCI 文章 1 篇。主要工作分为 3 个方面：

1. **土壤磷素化学转化过程：**分析了磷肥在土壤转化过程及影响因素，探索了钙质土壤和酸性土壤的磷吸附特征，以及 pH 变化对这些过程的影响。研究发现，磷肥颗粒进入土壤后，会形成宽 0-40mm，厚 0-60mm 的反应区间。而在这个反应区间中，因为磷酸根离子浓度和 pH 值的差异，会形成三个不同的反应区间，分别为直接反应区间（与钙和铁铝等形成直接反应，磷有效性较低），沉淀反应区间（形成无定形铁磷、铝磷或者二钙磷，磷有效性低）和吸附反应区间（羟基交换吸附磷、针铁矿吸附磷，有机质吸附磷，磷有效性高）。在酸性和钙质土壤中，pH 变化对磷的有效性存在显著影响。有机肥施用后会通过竞争吸附位点、阻碍晶体生长、降低表面电荷和物理吸附游离态磷方面提高土壤磷的有效性。分别在全系大会和 2010 年中国农大资环学院植物营养系年中总结会议做报告，并以合作作者在 Plant Physiology (1 区，影响因子 7.08) 发表文章 1 篇。

为了明确有机肥活化土壤磷的机理，于 2010 年在华中农业大学资环学院交流 3 个月，开展了磷在针铁矿表面的吸附和解吸机理的试验。试验目的是研究针铁矿对磷的化学吸附，以及加入胡敏酸和柠檬酸后对磷的解吸作用。初步研究结果表明，胡敏酸和柠檬酸可以解析针铁矿表面吸附的磷，但是解析程度随柠檬酸和胡敏酸的浓度增加而降低。有可能是小分子有机酸浓度的增加，增加了反应体系的离子强度，反而促进了解析磷的再吸附。

2. 土壤磷淋洗风险分析及优化措施：洛桑试验站的长期定位试验表明，在土壤有效磷和 $CaCl_2$-P 之间存在线性加拐点的关系，可用于表征土壤磷的淋洗和径流损失风险。基于此分析了北京市平谷地区农田土壤磷素淋溶风险。首先通过对平谷地区粮田、果园和菜地的磷素投入分析发现，菜地和果园的磷素年际磷盈余分别达到 498 和 468 kg P_2O_5 ha^{-1}，远大于粮田的 38 kg P_2O_5 ha^{-1}。这种状况造成粮田、菜地和果园土壤 Olsen-P 含量差异很大，分别为 18.4、44.3 和 40.4 mg kg^{-1}。分析钙质土壤 Olsen-P 与 $CaCl_2$-P 的相关性发现，钙质土壤存在着 Olsen-P 与 $CaCl_2$-P 突变拐点即磷的淋溶拐点，在拐点之后土壤 $CaCl_2$-P 随土壤 Olsen-P 的增加而显著增加，且土壤磷淋溶拐点明显受土壤类型及质地的影响。按质地分类，砂壤，轻壤和重壤拐点分别是 23.1，40.1 和 51.5 mg kg^{-1}，土壤质地由轻至重拐点 Olsen-P 值随之逐渐增加。根据质地模拟平谷地区磷素淋失风险，发现 7.7%的粮田，44.0%的菜田，33.6%的果园土壤磷淋失风险较高。该结果发表在农业环境科学学报，中文核心期刊。

为了降低土壤磷的淋溶风险，随后展开了室内培养实验，评价不同添加物在降低土壤磷素淋失风险的同时，对土壤生物有效磷的影响，以及这种作用随时间的变化。结果发现同等浓度条件下，氯化铝对 $CaCl_2$-P 降低效果明显优于硫酸铝和氯化铁，然而氯化铝也大幅度降低了土壤有效磷含量。而 $FeCl_3$ 以 1:1 摩尔比浓度与土混合后，Olsen-P 相对降低 14.9%，$CaCl_2$-P 相对降低 41.8%，较其他两种类型添加物是较优选择。不同物质施用后，可快速固定土壤中的磷素，而且这种固定作用并没有随着土壤干湿交替和时间变化有显著降低。

3. **土壤磷素管理模型：**作物和土壤 Olsen-P 之间存在线性加平台效应关系，可用于指导作物生产；而土壤 Olsen-P 和 $CaCl_2$-P 存在线性加拐点关系，可用于指导环境保护。通过对长期定位试验的土壤全磷和 Olsen-P 的总结，我们发现两者之间同样存在线性加拐点的

效应关系，这条曲线可以用于指导土壤磷素培肥。基于土壤全磷，Olsen-P，$CaCl_2$-P 和产量之间的关系，我们提出了我国土壤磷素管理模型。我们进一步研究发现，不同土壤类型的效应曲线存在较大差异，因此分别建立了不同土壤类型的磷素管理模型。该结果发表在 Plant and Soil 期刊（1 区，3.11）。

四、获得的科技/荣誉奖励及研究成果情况（代表性研究论文、专利、获奖等，标注排名）

发表论文：

[1]. **Bai, Z.**, Ma, L., Qin, W., Chen, Q., Oenema, O., Zhang, F. (2014). Changes in Pig Production in China and Their Effects on Nitrogen and Phosphorus Use and Losses. Environmental science & technology. 48: 12742−12749. **中科院 1 区，影响因子：5.87.**

[2]. **Bai, Z.**, Li, H., Yang, X., Zhou, B., Shi, X., Wang, B., ... & Zhang, F. (2013). The critical soil P levels for crop yield, soil fertility and environmental safety in different soil types. Plant and soil, 372(1-2), 27-37. **中科院 1 区，影响因子：3.11.**

[3] **Bai, Z. H.**, Ma, L., Oenema, O., Chen, Q., & Zhang, F. S. (2013). Nitrogen and phosphorus use efficiencies in dairy production in China. Journal of environmental quality, 42(4), 990-1001. **中科院 3 区，影响因子：2.60.**

[4]. Shen, J., Yuan, L., Zhang, J., Li, H., **Bai, Z.**, Chen, X., Zhang, W., Zhang, F.. (2011). Phosphorus Dynamics: From Soil to Plant. Plant Physiology. 156:997-1005. **中科院 1 区，影响因子：7.08.**

[5]. **柏兆海**, 万其宇, 李海港, 段增强, & 陈清. (2011). 县域农田土壤磷素积累及淋失风险分析——以北京市平谷区为例. 农业环境科学学报, 30(9), 1853-1860. **中文核心.**

参与编写书目：

[1]. 张福锁等著作. (2012). 高产高效养分管理技术. 北京：中国农业大学出版社.（参与第 8 章编写）.

[2].参与编写《设施番茄水肥一体化技术》、《设施黄瓜水肥一体化技术》、《设施番茄退化土壤修复技术》、《果类蔬菜中微量元素施肥技术》、《设施黄瓜最佳养分管理技术》和《设施番茄最佳养分管理技术》等技术服务手册。

国际学术会议论文集：

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[2]. **Bai, Z.**, Li, H., Shen, J., Chen, Q, Zhang, F. (2010) Dynamics and the critical value of soil Olsen-P for main crops in China. Fourth International Symposium on Phosphorus Dynamics in the Soil-Plant Continuum. Reference No: S2-41.

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五、提供两或三位同行具有高级职称推荐人的联系方式（姓名、职务、电话和邮箱地址）

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六、应聘岗位陈述（对岗位的认识、研究兴趣、应聘理由及优势、工作设想和其它说明）：

对岗位的认识：

首先，我认为从岗位的三个研究方向来看，需要应聘者具有食物链养分管理、畜牧养分流动以及模型方面的基础。同时需要较高的专业能力，如 SCI 写作，团队合作以及项目申请等。

其次，这个岗位设置具有重要意义。食物链管理和畜牧业生产的资源环境效应是目前国际研究热点，而我国在这些方面的研究还处于起步阶段。因此该岗位的设置引领了国内对食物链和畜牧业管理研究，同时也迎合了国家可持续农业发展需求。

研究兴趣：

个人研究兴趣为我国畜牧业生产体系资源利用和环境排放压力，以及优化措施；动物生长及饲料预测模型；畜禽生产粪尿管理和施用技术；农户尺度养分流动预测和监测模型。

应聘理由：

1. 本人对科研具有较深感情，愿意从事科研工作。并对此职位的研究方向非常有兴趣。
2. 本人专业背景和素质符合要求，且研究方向与课题组研究方向吻合。

优势：

1. 专业背景符合要求：硕士期间我主要从事土壤和作物研究，具有农学背景；而博士期间从事畜牧业养分流动研究，具有动物营养、饲料和模型研究背景。
2. 具有农业模型背景：博士期间主要课题是农田-畜牧体系的养分流动研究，学习使用了 NUFER 模型，并且通过研究建立了 NUFER-animal 模型，进一步优化了 NUFER 模型；对养分流动具有较深的理解和较好的建模能力。
3. 具有 SCI 写作经验和海外留学经历：本人具有 3 年以上海外访学经历，并且以第一作者发表 SCI 文章 3 篇，中文核心 1 篇，合作作者发表 SCI 文章 1 篇。其中 2 篇为中国科学院 1 区文章。
4. 本人责任感较强，博士期间能独立和按时完成课题任务，同时协助导师指导其他硕

士生以及博士生，并协助导师审稿和申请课题等。

工作设想：

1. **研究方向**：结合小组研究方向和国家未来需求，以及本人研究背景和基础，未来将主攻畜牧业养分管理及减排技术研究。主要研究方向有三个方面：

   （1）我国畜牧业资源和环境代价分析（包括饲料、耕地、水、温室气体分析，我国畜牧业养分流动特征，我国草地畜牧业历史变化及未来潜力，未来畜牧业生产结构优化设计等）；

   （2）农户尺度畜牧业养分管理模型（畜牧业产量差模型，农户尺度预测和监测模型，农户尺度不同养殖方式下养分和温室气体排放特征等）；

   （3）开发以及应用畜牧业减排技术（包括农牧结合体系设计，精确喂养技术，粪尿加工技术，以及粪尿施用技术等）。

2. **项目申请**：计划从 2015 年开始尝试申请国家自然基金、河北省基金和国际合作项目等。主要计划分三个方面：

   （1） 2015 年申请国家自然科学基金青年项目和省级项目；

   （2） 2016 年申请国家自然科学基金面上项目；

   （3） 2017 年申请国际合作项目或其他项目。

3. **文章和产出**：计划每年撰写和发表高影响因子 SCI 文章 1-2 篇，指导研究生撰写 SCI 文章 1 篇。

4. **国际合作**：加强和深化与国内外博士导师的合作，分为 3 个方面。

   （1） 深化与国外导师荷兰瓦赫宁根大学 Oene Oenema 教授的合作，尝试申请项目合作；

   （2） 建立与瓦赫宁根大学动物组（Imke de Boer 教授）和作物组（Jouke Oenema，奶牛养殖和管理专家）合作关系，尝试申请短期访问、合作指导研究生和博士生；

   （3） 加强和深化与国内硕士及博士导师的合作，尝试合作指导研究生以及申请项目。

5. **协助课题组长完成日常工作，申请项目以及项目总结，协助指导硕士和博士研究生等工作。**

七、附件：证明能力的：论文、证书影印件、其它材料等（PDF）

Environmental Science & Technology

Article

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Changes in Pig Production in China and Their Effects on Nitrogen and Phosphorus Use and Losses

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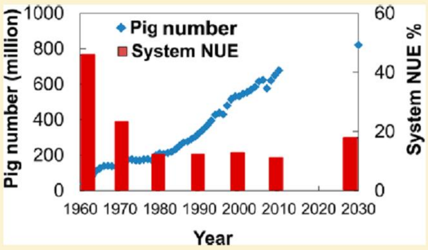
Supporting Information



ABSTRACT: China's pig production has increased manifold in the past 50 years, and this has greatly affected the nitrogen and phosphorus use and losses in the pig production sector. However, the magnitude of these changes are not well-known. Here, we provide an in-depth account of the changes in pig production—N and P use and total N and P losses in the whole pig production chain during the period 1960−2010—through simulation modeling and using data from national statistics and farm surveys. For the period of 2010−2030, we explored possible effects of technological and managerial measures aimed at improving the performances of pig production via scenario analysis. We used and further developed the NUtrient flows in Food chains, Environment and Resources use (NUFER) model to calculate the feed requirement and consumption, and N and P losses in different pig production systems for all the years. Between 1960 and 2010, pig production has largely shifted from the so-called backyard system to landless systems. The N use efficiencies at fattener level increased from 18 to 28%, due to the increased animal productivity. However, the N use efficiencies at the whole-system level decreased from 46 to 11% during this period, mainly due to the increase of landless pig farms, which rely on imported feed and have no land-base for manure disposal. The total N and P losses were 5289 and 829 Gg in 2010, which is 30 and 95 times higher than in 1960. In the business as usual scenario, the total N and P losses were projected to increase by 25 and 55% between 2010 and 2030, respectively. Analyses of other scenarios indicate that packages of technological and managerial measures can decrease total N and P losses by 64 and 95%, respectively. Such improvements require major transition in the pig production sector, notably, in manure management, herd management, and feeding practices.

INTRODUCTION

China had about 10% of the worlds' pig population in 1960, and nearly 50% in 2010.[1] The huge increase in the number of pigs during the last 50 years reflects the increasing importance of pork in the diet of Chinese people, concomitant with the economic growth and increase in income.[2] Most people can now afford pork, because of the relatively low price. Pork is part of the national "shopping basket program", which was initiated in the 1980s. This program encouraged landless livestock production to ensure to supply of cheap animal products to citizens.[3]

Pig production in China started some 7000 years ago, and for thousands of years, pigs were raised only in backyard systems.[4] Pigs served as a source of animal protein and energy for households and as a "converter" of crop residues and kitchen scraps into animal manure needed to fertilize cropland.[5] Animal productivity is quite low in backyard systems, mainly due to the inefficient indigenous pig species (e.g., Meishan, Luchuan, Jinhua), as well as the low quality and often low availability of feed.[2,4,5] New systems were introduced when prime minister Deng Xiaoping started the policy reforms in 1978, and the economy started to grow. The institution of industrial pig farms began in the second half of the 1990s.[4,6] As a result of the policy reform and free-trade agreements that liberalized and industrialized the whole pork sector, more efficient pig species were introduced, such as Duroc, Landrace, and Yorkshire.[2,4] The increase in pig production in landless, medium-sized, and industrial systems from 1990s onward (Figure 1) coincided with the rapid changes in the structure of the pig production sector,[5−7] and with a strong increase in the production of corn in China and the import of soybean from oversees. [1]

An increasing fraction of the pork produced is coming now from landless, industrial pig production systems, which purchase nearly all feed from other farms and regions, whereas decreasing fractions are produced by the traditional and backyard systems that rely mostly on on-farm produced residues and feeds.[2] The structural changes in pig production also led to changes in regional distributions. The top three biggest producers of pork are still the provinces Sichuan,

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NUTRIENT MANAGEMENT CHALLENGES AND PROGRESS IN CHINA

Nitrogen and Phosphorus Use Efficiencies in Dairy Production in China

Z.H. Bai and L. Ma, O. Oenema, Q. Chen, and F.S. Zhang*

Milk production has greatly increased in China recently, with significant impacts on the cycling of nitrogen (N) and phosphorus (P). However, nutrient flows within the changing dairy production system are not well quantified. The aim of this study was to increase the quantitative understanding of N and P cycling and utilization in dairy production through database development and simulation modeling. In 2010, of the entire 1987 and 346 thousand tons (Gg) of N and P input, only 188 Gg N and 31 Gg P ended up in milk. The average N and P use efficiencies were 24 and 25%, respectively, at the whole system level. Efficiencies differed significantly between the four dairy systems. Losses of N from these systems occurred via NH_3 volatilization (33%), discharge (27%), denitrification (24%), NO_3^- leaching and runoff (16%), and N_2O emission (1%). Industrial feedlots use less feed per kg milk produced than traditional systems, and rely more on high-quality feed from fertilized cropland; they have very poor recycling of manure nutrients to cropland. As industrial feedlot systems are booming, overall mean N and P use efficiencies will increase at herd level but will decrease at the whole dairy production system level unless manure N and P are used more efficiently through reconnecting China's feed and dairy production sectors.

Chinese Prime Minister Wen Jiabao once said he had a dream that "all Chinese, especially children, can drink a half a liter of milk per day" (Xinhua News, 2006). If his dream had come true, the total milk consumption in China would have been 244 million tons in 2010, nearly 7 times the actual milk production at that time. Whether the dream comes true or not, forecasts suggest that the average milk consumption per capita will continue to increase in the near future. Average milk consumption per capita has increased in China from 2.9 kg yr^{-1} in 1961 to 31 kg yr^{-1} in 2007. Despite this 10-fold increase, the consumption level was still only 10% of the mean milk consumption level of the United States in 2007. The world average milk consumption in 2007 was about 2.3 times higher than the average of China in 2007 (FAO, 2011).

The increased milk consumption has boosted milk production in China. Most of the increased production has been achieved through increasing the number of dairy cattle. In 2007, the number of dairy cows in China was larger than the number in the United States, one of the biggest milk producers in the world, but total milk production was only 40% of the production in the United States (FAO, 2011). Mean annual milk yield in China was 2882 kg per cow in 2010, whereas annual averages for the United States and the world were 9595 and 2328 kg per cow, respectively (FAO, 2011). The relatively low milk yield per cow in China is related to poor-quality feed, the limited genetic potential of dairy cows, and poor herd management. However, there is a huge diversity in dairy farming systems, and there is little quantitative information about feed use and nutrient flows within these systems. There are a few reports about the efficiency of milk production on individual dairy farms (e.g., Powell et al., 2008), but there are no comprehensive overviews of "feed production–dairy herd–milk production" on various dairy production types in China.

The efficiency of milk production can be expressed in terms of feed consumption per kg of milk (and beef) produced but also in terms of nitrogen (N) and phosphorus (P) use per kg of milk and beef produced (Powell et al., 2010). Efficiency expressed in terms of N and P used per kg of milk produced has relevance

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Abbreviations: BNF, biological nitrogen fixation; DM, dry matter; LWG, live weight gain; MW metabolic weight; MY, milk yield; NUE, nitrogen use efficiency; PUE, phosphorus use efficiency.

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REGULAR ARTICLE

The critical soil P levels for crop yield, soil fertility and environmental safety in different soil types

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Abstract
Background and aims Sufficient soil phosphorus (P) is important for achieving optimal crop production, but excessive soil P levels may create a risk of P losses and associated eutrophication of surface waters. The aim of this study was to determine critical soil P levels for achieving optimal crop yields and minimal P losses in common soil types and dominant cropping systems in China.
Methods Four long-term experiment sites were selected in China. The critical level of soil Olsen-P for crop yield was determined using the linear-plateau model. The relationships between the soil total P, Olsen-P and $CaCl_2$-P were evaluated using two-segment linear model to determine the soil P fertility rate and leaching change-point.
Results The critical levels of soil Olsen-P for optimal crop yield ranged from 10.9 mg kg^{-1} to 21.4 mg kg^{-1}, above which crop yield response less to the increasing of soil Olsen-P. The P leaching change-points of Olsen-P ranged from 39.9 mg kg^{-1} to 90.2 mg kg^{-1}, above which soil $CaCl_2$-P greatly increasing with increasing soil Olsen-P. Similar change-point was found between soil total P and Olsen-P. Overall, the change-point ranged from 4.6 mg kg^{-1} to 71.8 mg kg^{-1} among all the four sites. These change-points were highly affected by crop specie, soil type, pH and soil organic matter content.
Conclusions The three response curves could be used to access the soil Olsen-P status for crop yield, soil P fertility rate and soil P leaching risk for a sustainable soil P management in field.

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Phosphorus Dynamics: From Soil to Plant[1]

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With increasing demand of agricultural production and as the peak in global production will occur in the next decades, phosphorus (P) is receiving more attention as a nonrenewable resource (Cordell et al., 2009; Gilbert, 2009). One unique characteristic of P is its low availability due to slow diffusion and high fixation in soils. All of this means that P can be a major limiting factor for plant growth. Applications of chemical P fertilizers and animal manure to agricultural land have improved soil P fertility and crop production, but caused environmental damage in the past decades. Maintaining a proper P-supplying level at the root zone can maximize the efficiency of plant roots to mobilize and acquire P from the rhizosphere by an integration of root morphological and physiological adaptive strategies. Furthermore, P uptake and utilization by plants plays a vital role in the determination of final crop yield. A holistic understanding of P dynamics from soil to plant is necessary for optimizing P management and improving P-use efficiency, aiming at reducing consumption of chemical P fertilizer, maximizing exploitation of the biological potential of root/rhizosphere processes for efficient mobilization, and acquisition of soil P by plants as well as recycling P from manure and waste. Taken together, overall P dynamics in the soil-plant system is a function of the integrative effects of P transformation, availability, and utilization caused by soil, rhizosphere, and plant processes. This Update focuses on the dynamic processes determining P availability in the soil and in the rhizosphere, P mobilization, uptake, and utilization by plants. It highlights recent advances in the understanding of the P dynamics in the soil/rhizosphere-plant continuum.

P DYNAMICS IN SOIL

Soil P Transformation

Soil P exists in various chemical forms including inorganic P (Pi) and organic P (Po). These P forms differ in their behavior and fate in soils (Hansen et al., 2004; Turner et al., 2007). Pi usually accounts for 35% to 70% of total P in soil (calculation from Harrison, 1987). Primary P minerals including apatites, strengite, and variscite are very stable, and the release of available P from these minerals by weathering is generally too slow to meet the crop demand though direct application of phosphate rocks (i.e. apatites) has proved relatively efficient for crop growth in acidic soils. In contrast, secondary P minerals including calcium (Ca), iron (Fe), and aluminum (Al) phosphates vary in their dissolution rates, depending on size of mineral particles and soil pH (Pierzynski et al., 2005; Oelkers and Valsami-Jones, 2008). With increasing soil pH, solubility of Fe and Al phosphates increases but solubility of Ca phosphate decreases, except for pH values above 8 (Hinsinger, 2001). The P adsorbed on various clays and Al/Fe oxides can be released by desorption reactions. All these P forms exist in complex equilibria with each other, representing from very stable, sparingly available, to plant-available P pools such as labile P and solution P (Fig. 1).

In acidic soils, P can be dominantly adsorbed by Al/Fe oxides and hydroxides, such as gibbsite, hematite, and goethite (Parfitt, 1989). P can be first adsorbed on the surface of clay minerals and Fe/Al oxides by forming various complexes. The nonprotonated and protonated bidentate surface complexes may coexist at pH 4 to 9, while protonated bidentate innersphere complex is predominant under acidic soil conditions (Luengo et al., 2006; Arai and Sparks, 2007). Clay minerals and Fe/Al oxides have large specific surface areas, which provide large number of adsorption sites. The adsorption of soil P can be enhanced with increasing ionic strength. With further reactions, P may be occluded in nanopores that frequently occur in Fe/Al oxides, and thereby become unavailable to plants (Arai and Sparks, 2007).

In neutral-to-calcareous soils, P retention is dominated by precipitation reactions (Lindsay et al., 1989), although P can also be adsorbed on the surface of Ca carbonate (Larsen, 1967) and clay minerals (Devau et al., 2010). Phosphate can precipitate with Ca, generating dicalcium phosphate (DCP) that is available to plants. Ultimately, DCP can be transformed into more stable forms such as octocalcium phosphate and hydroxyapatite (HAP), which are less available to plants at alkaline pH (Arai and Sparks, 2007). HAP accounts for more than 50% of total Pi in calcareous soils from long-term fertilizer experiments (H. Li, personal communication). HAP dissolution increases with decrease of soil pH (Wang and Nancollas, 2008), suggesting that

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县域农田土壤磷素积累及淋失风险分析
——以北京市平谷区为例

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摘　要：作物的磷素需求和投入的差异导致土壤磷素积累对环境的影响不同。通过分析京郊平谷区果树、蔬菜和粮食作物的磷素投入数量和农田土壤有效磷含量，比较研究不同作物体系中土壤磷素积累对环境的影响。结果表明，粮田、菜地和果园平均年际磷投入量分别为 76、575 kg $P_2O_5 \cdot hm^{-2}$ 和 693 kg $P_2O_5 \cdot hm^{-2}$，其中菜地和果园的磷素投入以有机肥为主，年际磷盈余分别达到 498 kg $P_2O_5 \cdot hm^{-2}$ 和 468 kg $P_2O_5 \cdot hm^{-2}$，远大于粮田的磷素盈余(38 kg $P_2O_5 \cdot hm^{-2}$)。这种状况造成粮田、菜地和果园土壤 Olsen-P 含量差异很大，分别为 18.4 (n=260)、44.3 (n=108) $mg \cdot kg^{-1}$ 和 40.4 $mg \cdot kg^{-1}$ (n=548)。分析钙质土壤 Olsen-P 与 $CaCl_2$ 浸提 P 的相关性发现，钙质土壤存在着 Olsen-P 与 $CaCl_2$-P 突变拐点即磷的淋溶拐点，在拐点之后土壤 $CaCl_2$-P 随土壤 Olsen-P 的增加而显著增加，且土壤磷淋溶拐点明显受土壤类型及质地的影响。按质地分类，砂壤、轻壤和重壤拐点分别是 23.1、40.1 $mg \cdot kg^{-1}$ 和 51.5 $mg \cdot kg^{-1}$，土壤质地由轻至重拐点 Olsen-P 值随之逐渐增加。根据质地模拟，7.7%的粮田、44.0%的菜田、33.6%的果园土壤磷淋失风险较高。因此，合理的磷素投入在果树、蔬菜作物的可持续生产中具有重要的意义。

关键词：Olsen-P；$CaCl_2$-P；拐点；磷淋溶风险；粮田；果园；菜田
中图分类号：X820.4　　文献标志码：A　　文章编号：1672-2043(2011)09-1853-08

Evaluation of Soil Phosphorus Accumulation and Loss Risk on Arable Land at County Level: The Example of Pinggu District, Beijing City, China

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Abstract: The variation of phosphorus demand and input among different cropping system may cause the different surplus and risk to environment. The aim of this study is to evaluate the difference of soil phosphorus (P) accumulation and potential risk of P loss to environment among cereal, fruit and vegetable cropping systems in Pinggu District, Beijing suburb, through field survey on phosphorus application and soil analysis. The results showed that the average P input was 76, 575 kg $P_2O_5 \cdot hm^{-2} \cdot a^{-1}$ and 693 kg P_2O_5 $hm^{-2} \cdot a^{-1}$ in cereal, vegetable and orchard systems, respectively. Manure P was the main proportion of the total P input in vegetable and orchard systems and P surplus was 468 kg $P_2O_5 \cdot hm^{-2} \cdot a^{-1}$ and 498 kg $P_2O_5 \cdot hm^{-2} \cdot a^{-1}$, which was much higher than that in cereal system (38 kg $P_2O_5 \cdot hm^{-2} \cdot a^{-1}$). This caused high variation in soil Olsen-P content, which was 18.4, 44.3 $mg \cdot kg^{-1}$ and 40.4 $mg \cdot kg^{-1}$ for cereal (n=260), vegetable (n=108) and orchard (n=548) system, respectively. It was found that there were change-points when soil $CaCl_2$-P rapid increased with soil Olsen-P was 23.1, 40.1 $mg \cdot kg^{-1}$ and 51.5 $mg \cdot kg^{-1}$ for sandy loam, light loam and heavy loam soils, respectively, through the correlation analysis between soil Olsen-P and $CaCl_2$ extracted P contents. The value of change-point was significantly higher in clay soils than loam soils. As classified with soil texture, 7.7%, 44.0% and 33.6% of the surveyed fields were with high P leaching potential in cereal, vegetable and orchard cropping system, respectively. It is necessary to manage P input in vegetable and orchard system following crop requirement and soil P fertility.

Keywords: Olsen-P; $CaCl_2$-P; change-point; P leaching risk; cereal; vegetable; orchard

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